IBM® Customer Engineering Reference Manual

736 Power Supply

741 Power Supply

746 Power Distribution Unit

CONTENTS

NOTICE

Each different unit, item and test of this machine has been assigned a "Reference Manual Code Number." This code number is located in the tens and units position of each section number. All numbers over .50 have been assigned to waveshapes in each section. Therefore, waveforms between each manual will not have the same numbers. Numbers in the tape drive also will differ.

The following index chart can be used to find the location of the appropriate maintenance information.

	Clean/Inspect	Removals	Adjustments/ Timings
08 Relays	PF.14.08	PF.21.08	PF.22.08

CODE
NUMBER

Figures may be larger than one page so are put on two or more pages. The same figure number is used on all pages and are defined by a letter following the figure number. As an example: 60-1a, 60-1b.

MAINTENANCE INDEX CHART						
AREA	REF. MAN CODE NO.	ITEM	CLEAN & INSPECT	WAVE FORMS & LEVELS	REMOVALS	ADJUST. & TIMINGS
POWER	02	Filters and Appearance	PF.14.02		PF.21.02	
DISTRIBUTION	04	Terminals and Connections	PF.14.04			
FRAME	06	Neons	PF.14.06		PF.21.06	
	07	Buttons, Keys and Switches	PF.14.07		PF.21.07	
	08	Relays and Contactors	PF.14.08		PF.21.08	PF.22.08
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	12	Fuses, Clips and Bails	PF.14.12			PF.22.12
	17	Ripple Content		PF.15.17		
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	26	Meters, Sensitrol Meters	PF.14.26			
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FRAMES	02	Filters and Appearance	PF.14.02		PF.21.02	
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	04	Terminal Connections	PF.14.04			
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	09	Capacitors and Rectifiers	PF.14.09		PF.21.09	
	10	Rectifier Tubes	PF.14.10			
	12	Fuses, Clips and Bails	PF.14.12			PF.22.12
	20	Timer Assembly	PF.14.20			PF.22.20
	27	Hi-Lo Circuit				PF.22.27

PF.10.00 PREVENTIVE MAINTENANCE

A customer engineer is called upon to perform two types of maintenance - corrective and preventive. Corrective maintenance is the finding and correcting of a trouble after it has occurred. Preventive maintenance is the work which is performed on a regularly scheduled basis to correct potential trouble, minimize service calls, and maintain machine availability to the customer.

The importance of regularly scheduled preventive maintenance is shown in two ways. First, it is important to the customer, because the work is done on the machine during off-peak load periods. Second, it is important to the customer engineer, because it enables him to schedule his activities and use his time to the greatest advantage.

By applying preventive maintenance techniques, more machine time is available to the customer. Overscheduling of preventive maintenance is as undesirable as underscheduling. The objective is to increase machine availability to the customer by reading total maintenance time.

For the first three months of operation, preventive maintenance should be performed as recommended in section PF.12.00 (P.M. Procedure). By this time, the customer engineers of each installation should have filled in the frequency of inspection on the P.M. Guide and Record (Section PF.11.00). Also by this time, they should have developed their own preventive maintenance schedule.

PREVENTIVE MAINTENANCE GUIDE AND RECORD

736-741-746
POWER SUPPLY

SERIAL	SUFFIX	DATE INSTALLED

CODE NO. FOR 736 – 741 – 746 REF. MANUAL

FREQUENCY OF INSPECTION IN MONTHS

YR.

MO.

			*												
RECTIFIER TUBES															
RIPPLE CONTENT OF D. C. VOLTAGES (PEAK TO PEAK)		+150 (± 250MV)													
		+220 (± 50MV)													
		−250 (± 250MV)													
		−100 (± 250MV)													
		−30 (± 250MV)													
		+15 (± 500MV)													
		−130 (± 5V)													
TUBE TEST		VOLTAGE CONTROL													
		RIPPLE SURPRESSOR													
		A. C. LINE REGULATOR													
RELAYS															
AIR FILTERS															

PREVENTIVE MAINTENANCE GUIDE
753 TAPE CONTROL UNIT

Rectifier Tubes

Each week inspect the rectifier tubes visually to check for tubes that are not firing, that are overheating, or that give any indication of faulty operation.

Ripple Content of DC voltages
Freq. Time
1 yr. 0.1 hr.

With the master oscillator disconnect, use an oscilloscope and check each supply at the P. D. F. for noise. Maximum ripple for each supply should be:

Supply	Ripple
+150	± 250 MV. Peak to Peak
+220	± 50 MV. Peak to Peak
- 250	± 250 MV. Peak to Peak
- 100	± 250 MV. Peak to Peak
- 30	± 250 MV. Peak to Peak
+ 15	± 500 MV. Peak to Peak
- 130	± 5 V. Peak to Peak

The ripple content for each supply should be recorded for future reference.

Tube Test
Freq. Time
12 mo. 4 hr.

Test tubes in the voltage control units, ripple suppressors and AC Line Regulators, and replace those that are weak, shorted, or give indication of faulty operation.

Terminal Connections

Check all terminal connections for indications of corrosion, overheating, or looseness.

Relays
12 mo. .4 hr.

Check all relays for coils that give indication of overheating, dirty or pitted points, air gap and rise, and binding pivots.

Air Filters
2 mo. .4 hr.

Inspect air filters and replace all those that will impede air flow because of dirt.

Visual inspection of rectifier tubes and ripple checks may be done while the customer is operating.

Fuses may be tested for high resistance by measuring voltage drop across fuse.

Several months after installation check all terminal connections for indications of corrosion, overheating, or looseness.

PF. 13.00 LUBRICATION CHART

The Power Frame Unit should be lubricated on the average of once every three months, unless trouble occurs from the lack of lubrication.

Code No.	Description	Type of Lubrication				
		6	9	12	17	20
2	Cover and door hinges		X			
2	Cover latch cams				X	
2	Cover door rollers		X			
8	Duo relay pivots (pipe cleaner)		X			
8	Duo relay operating pads (light film)				X	
8	Wire relay pivot		X			
8	Wire relay latch (if latch type)		X			

PF.14.00 CLEAN AND INSPECT

PF.14.02 Filters and Appearance

Check all covers for good latching and unlatching clearance. Check power frame panels for a good air flow. Replace all filters that are dirty. Clean all covers with IBM polish. Clean any large accumulations of dust or dirt with an approved vacuum cleaner.

PF.14.03 Motors and Blowers

Check motors with power off to be sure they are free running and the motor shafts do not bind. Check to be sure the bearing housings are not running hot and the blower for a quiet running operation. Check for a good air flow in all panels and be sure there are no unusual hot spots. Methods to check the operating temperatures of panels and bearings are found in Section 704.14.01.

PF.14.04 Terminal Connections

Check all terminal connections for indications of corrosion, overheating, looseness, grounded or shorted connections. Pay particular attention to the heavy cable where it enters the lower left swinging door of the 746. The door wears and breaks the insulation on the cable grounding it out to the frame.

PF.14.05 Thermals and Contacts

Check the thermal light for proper operation. Check the contacts for alignment and clean the points for a good "make" surface. Be sure power is knocked down on thermal operation. Check connections to see none are loose, grounded or shorted out. The thermals are set to operate at 131° ± 5° F. Make sure that with all covers off the thermals operate and knock down power. Section 704.14.05 contains a complete description and adjustments on thermals.

PF.14.06 Neons, Buttons, Keys and Switches

Neon Lamp Assembly

Check to be sure all the neon lamps work correctly.

Keys, Buttons and Knobs

Clean any dirty keys, buttons or knobs with a detergent and warm water. Do not use tape developer or cleaners because the plastic is attacked by many of these. Check to make sure none of the keys are binding or broken.

PF.14.07 Jones Plugs and Sockets

Check for loose or grounded connections. Check for any burned or dirty contacts.

PF.14.08 Relays and Contactors

Contactors

Check all contactors for coils that give indications of overheating or for points that are burned or pitted. Check for loose, grounded, or shorted connections. The contacts of all Allen-Bradley type contactors are composed of a cadmium silver alloy. Oxides which form on these contacts are good electrical conductors. Therefore, the contacts never need filing or dressing. When they are dirty, wipe clean with a dry cloth. The contacts of Arrow-Hart type contactors are of heavy copper construction with silver alloy tips. These tips oxidize more slowly than copper tips and the oxide which does form tends to be self-reducing. Therefore, it is not necessary to file these tips. The tips must not be filed since the silver surface is very thin and filing destroys the contact. Never lubricate the contact face because the burning of the oil on circuit interruptions increase the heating of the tips and shortens the life of the contact.

Relays

Check relays for loose connections, dirty or pitted points, and for binding armature pivots. See Section 704.14.08 for a complete P. M. procedure on relays.

PF.14.09 Capacitor Banks and Selenium Rectifiers

Check voltages for ripple. Excessive ripple is a sign of blown capacitors. Visually check for loose connections for blown expansion plugs. Check for any hot spots or other trouble indications on both capacitors and selenium rectifiers.

PF.14.10 Rectifier Tubes

Each week make a visual check of the rectifier tubes. Check for any tubes not firing, overheating or that give any indication of faulty operation.

PF.14.12 Fuses, Fuse Clips and Fuse Bails

Check for loose connections, bent or loose clips, or loose fuses. Check for any hot spots or burned conditions. Check for proper fuse bail operation.

PF.14.20 Timer Assembly

Check to make sure timer arm is not binding. Check for proper time duration and proper operation. Check microswitches to be sure they make and break correctly.

PF.14.25 Buzzer Assembly

Check buzzer for correct operation in the filament regulation hi-lo circuit.

PF.14.26 Meters, Sensitrol Meters

Check all meters for proper reading. Calibrate with a standard meter when the reading is suspicious. Check sensitrol meter for correct operation and the monitors for each one. Make sure the reset arms reset the sensitrol meters correctly.

PF.15.00 VOLTAGES AND LEVELS

PF.15.17 Ripple Content

With the master oscillator disconnected, use an oscilloscope and check each supply at the P. F. for ripple and noise. Following are the allowable limits.

SUPPLY	PEAK TO PEAK RIPPLE
+150	± 250MV
+220	± 50MV
-250	± 250MV
-100	± 250MV
- 30	± 250MV
+ 15	± 500MV
-130	± 5V

PF. 21. 00 REMOVALS

PF. 21. 02 Filters

There are three filters in the two power supply frames. They are removed by opening the back covers and removing the two screws from the small holding strip at the bottom of each filter. The filters can be lifted out.

PF. 21. 03 Motors and Blowers

Make sure all power is down and after the filters are removed the motor and blower is held to the frame by four bolts.

PF. 21. 06 Neons, Buttons, Keys and Switches

Most all keys, buttons and switches are held to the respective shafts by setscrews. The shafts are held to the panel by screws.

Indicator lamps on the front of the panel are replaced by pushing and twisting. The blown fuse indicator neons are just stuck through a grammet and the leads are soldered to terminals.

PF. 21. 07 CE Test Panel

Almost all components are held to the panel by screws and can be removed this way.

PF. 21. 08 Relays

The duo relays located in the power supply frames and the relays located in the power distribution frame are held to the base by screws.

PF. 21. 09 Resistors, Transformers, Power Chassis

Each power supply voltage is located in a chassis or drawer and these are mounted on slides which are removed by removing the holding screw on each side and sliding it out. Be sure power is down before working on any power supply. Resistors, capacitors, chokes, transformers and all components are mounted to these sliding power chassis. Be careful in handling these chassis as some are extremely heavy.

PF. 22. 00 ADJUSTMENTS

PF. 22. 01 General Heat Problems

Check Section 704. 14. 01 for methods to correct and test heat problems.

PF. 22. 08 Relays

For the five duo relays in the power supply frames as well as the special contactors and relays in the power distribution frame, see Section 704. 22. 08 and 704. 14. 08 for the maintenance and adjustments for each type of relay. Use same adjustment for the monitor key contacts as for the operators panel key contacts.

PF. 22. 09 Bleeder Resistors

The slide resistors which are used for bleeder resistors in the -30v and +15v power supplies are located in both the front and back side of the right hand resistor panel. The resistor numbers are found on Systems Diagrams, 9. 29, sheet 4 of 5.

The method of using the resistors in circuit logic is found in Systems Diagrams, 9. 29, sheet 1 of 5. Numbers 2-25 are located on the outside of the resistor panel and 32-60 are located on the inside of the resistor panel.

There are several methods used in adjusting these adjustable slide resistors. In the chart below is given the ohmic resistance from the slide terminal to ground. This value is pre-set before power is applied. After power is brought up, a good DC meter is used and the slide can be adjusted slightly to get either the +10v or -30v output. The adjustment should be slight from the original setting and must be done only with power down. Under no circumstances will the slide be adjusted more than halfway toward the ground end of the resistor to get the +10 volt output.

Another method that may be used is to set the slide resistors for minimum resistance and then measure the voltage at the input terminal. Be sure the voltage supply is adjusted so the input is very close +15v or -30v. Adjust the slide for the exact voltage needed for the output. Again be sure the slide is never adjusted past the halfway point toward the ground end for the +10v output.

Resistor Number	Res. Value	Adj. Value	Remarks
2 Series	10 ohms	Fixed	-30 volts
3	10 ohms	Fixed	-30 volts
4 Parallel	50 ohms	44 ohms	-30 volts *
5	50 ohms	44 ohms	-30 volts *
7	10 ohms	Fixed	-30 volts
8	5 ohms	Fixed	-30 volts
9	25 ohms	21.4 ohms	-30 volts
10	25 ohms	Fixed	-30 volts
12 Series	50 ohms	Fixed	-30 volts #
13	25 ohms	64. 2 ohms	-30 volts #
14 Series	50 ohms	Fixed	-30 volts #
15	5 ohms	53. 2 ohms	-30 volts #
25 Series	25 ohms	Fixed	-30 volts #
19	25 ohms	43.6 ohms	-30 volts #
20	100 ohms	Fixed	-30 volts
32	5 ohms	3. 3 ohms	+15 volts
33	5 ohms	3. 3 ohms	+15 volts
34	10 ohms	6 ohms	+15 volts
35	10 ohms	7. 9 ohms	+15 volts
36	10 ohms	7. 9 ohms	+15 volts
37	10 ohms	6.7 ohms	+15 volts
38	5 ohms	3. 3 ohms	+15 volts
39 Parallel	10 ohms	6.4 ohms	+15 volts *
40	10 ohms	6.4 ohms	+15 volts *
42	10 ohms	6. 1 ohms	+15 volts
43	10 ohms	9. 2 ohms	+15 volts
44	10 ohms	8. 5 ohms	+15 volts
45	10 ohms	6 ohms	+15 volts
46 Series	25 ohms	Fixed	-30 volts #
47	10 ohms	32 ohms	-30 volts #
48	25 ohms	13. 9 ohms	+15 volts
49	5 ohms	3. 3 ohms	+15 volts
50	5 ohms	3. 3 ohms	+15 volts

Resistor Number	Res. Value	Adj. Value	Remarks
51 ┐ Series	10 ohms	Fixed	-30 volts #
52 ┘	10 ohms	19.6 ohms	-30 volts #
53 ┐ Series	25 ohms	Fixed	-30 volts #
54 ┘	10 ohms	29.5 ohms	-30 volts #
55 ┐ Parallel	50 ohms	45 ohms	-30 volts *
56 ┘	50 ohms	45 ohms	-30 volts *
57 ┐ Series	10 ohms	Fixed	-30 volts
58 ┘	10 ohms	Fixed	-30 volts
59 ┐ Parallel	50 ohms	42 ohms	-30 volts *
60 ┘	50 ohms	42 ohms	-30 volts *

All resistors are 100 watt resistors.

Jumpers of series combination left on and resistance measured over combination.

* Jumpers of parallel combinations are removed and resistance measured over each separate resistor.

PF. 23.00 CORRECTIVE MAINTENANCE

PF. 23.12 Fuses

Fuses in the power supply are found behind the control panel door. Marker strips identifying the fuses and their circuit designation numbers are located adjacent to each group of fuses. In general the top third of the fuse panel is made up of DC fuses, the center third regulated AC fuses and lower third unregulated AC fuses.

Alarm bars are used with all fuse divisions. They are arranged so that when a DC fuse blows, a DC off signal is originated and when an AC fuse blows, a normal off signal is originated. Either of these signals picks one of the latch type relays associated with that voltage group. It is impossible to start a DC on or power on sequence until the blown fuse is removed, and the interlocking relay for the supply containing the blown fuse has been reset. Look for the latched relay first - it will indicate in which group the blown fuse is located.

Each DC voltage is distributed to the main frame in fifteen sections, each section separately fused. Systems 9.29, sheet 3 has a diagram of the CPU panels showing the fuse sections. Each contains twenty pluggable units. On sheet 4 a chart gives the fuse number for each voltage in each section, the location on systems 9.17, the binder posts in the PDF and MF and the MF edge connector for each supply line.

Voltage distribution to the core and drum frames is similar except that each pluggable unit panel is fused separately because there are no sections. Binder post terminal drawings are labeled directly on 9.30.03 and 9.32 sheet 3. These lines can be traced back to 9.17.

In addition to the DC fuses shown on 9.17, charts on 9.18 and 9.19 show regulated and unregulated AC fuses respectively. Additional AC fuses for everything in the 2 power frames, but blowers, are located in the power frames and listed on 9.24, 9.25, 9.26 and 9.27.

PF. 23.20 Hayden Timer Assembly

The make and break microswitches should be adjusted so the switches are made while the arm assembly has .010" more travel. Check arm to be sure it is tight on the timer arm and in line with the operating lever of the microswitch.

PF. 23.27 Hi-Lo Circuit

On Systems Diagrams 9.13.02, page 2 of 2, each line must be set at 120 ± 5 volts by the regulated voltage adjustment screw. These regulated AC lines can be adjusted while DC is coming up. Use the selector switch and meter on the distribution panel to observe this reading. Attach a high impedance DC meter between pin 2 of T-B04 and the plus side of capacitor C-B01. This is the red lead to the capacitor and is located on Systems Diagrams 9.13.02, sheet 1. The course adjustment is turned for a maximum reading of the attached meter. The fine adjustment is then used to peak the reading. The reading should be 100 volts or slightly higher. This adjustment should then give these results: If the line voltage is raised to 125 volts, the attached meter should drop to about 50 volts and the hi-lo circuit should operate if the line voltage is dropped to 115 volts the attached meter reading should go to a reading of about 50 volts and the hi-lo circuit should operate. These adjustments must be made slowly because of the long time constants associated with capacitance C-B01 and the regulator relay coil. The relay must be checked for burned points. High contact resistance changes the time constant and also the operating point of hi-lo circuit.

The load compensation adjustment is set at the factory and should not be changed in the field. If it is adjusted an external adjustable load is needed. It is set by adjusting lines at 120 volts at no external load. The load is increased in steps of two or three amps at a time. The load compensator is used to hold the line voltage at 120 volts for any external load. The accepted allowance is a 10% change of line voltage for full load change.

PF.41.00 DC POWER OFF CAUSES

PF.41.01 Voltage Monitors

Weston Sensitrol meters determine whether output voltages of DC supplies are within proper limits. The monitor has a D'Arsonval movement with the moving arm acting as a relay contact (Figure 41-1, Pin 1). With normal DC voltage the moving arm contact is held in the center of the meter scale, midway between fixed contacts (Pins 4 and 5). If the voltage departs from the limit shown on the meter face, the moving arm strikes one of the fixed contacts completing a circuit to relay K247 (Systems Diagrams 9.02, Sheet 4 of 7). These relay points initiate a DC off in the machine. The reset arm is actuated during a DC on or power on sequence. The reset is energized while power is building up until 30 seconds after power is up. The reset arm moves the contact arm to the midpoint of the scale.

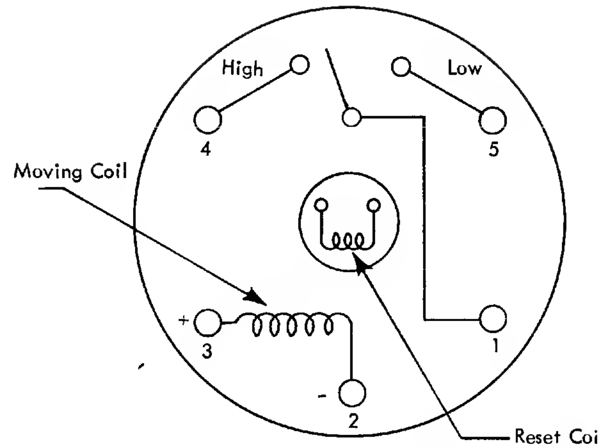


FIGURE 41-1. VOLTAGE MONITOR - WIRING SIDE

PF.41.02 Bias Fuse Monitors

A monitor and a neon are connected across the fuses of the -100 and -250v supplies. This knocks down power in case a fuse were to blow without the plunger operating. A similar circuit is provided on the +15v to aid the customer engineer (Figure 41-2 and 41-3). Loss of the +15 volt supply causes borderline troubles that are extremely difficult to analyze. If a fuse is blown in any of the three supplies, and its plunger failed to complete a circuit which initiates a DC off, the bias monitor is activated and relay 275 and 276 are picked. These relay points initiate a DC off (Systems Diagrams 9.02, Sheet 4 of 7).

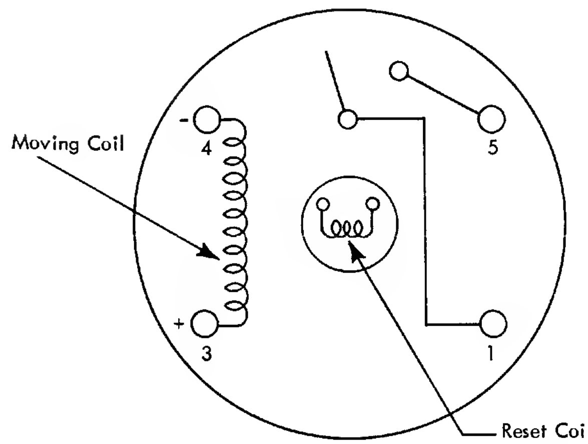


FIGURE 41-2. -100V AND -250V BIAS VOLTAGE FUSE MONITOR-WIRING SIDE

PF.41.03 Power Supply Open Fuse Neon

When any fuse in the three power supply frames blows, the power supply open fuse neon comes on (Systems Diagrams 9.02, Sheet 1 of 7). Behind the control panel door are located the open fuse neon for frame 1 and frame 2, and these indicate in which power frame the blown fuse has occurred. If neither of the two neons are on, the blown fuse is in the power distribution frame. See Figure 41-4 for fuse and controlling relay numbers. This initiates a DC off sequence.

PF.41.04 Voltage Off-Limit Neon

The voltage off-limit neon comes on when one of the DC voltages varies enough to cause the corresponding voltage monitor to initiate a DC off operation (Systems Diagrams 9.02, Sheet 4 of 7).

PF.41.05 Circuit Breakers

Magnetic circuit breakers cause a DC off sequence if the current in any unregulated AC input line to a rectifier becomes excessive because of a line fault or internal short circuit in the rectifier. A circuit breaker is opened by current transformers in each input line. Secondaries of the current transformers are connected to the operating coils of the circuit breaker. By choosing the various output taps of the current transformer secondary, the current used to actuate the circuit breaker can be varied to achieve the operating time desired, (Figure 43-1 and Systems Diagrams 9.23).

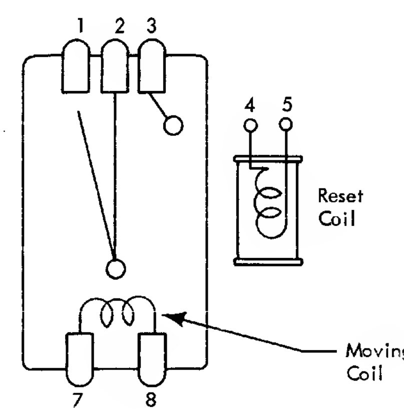
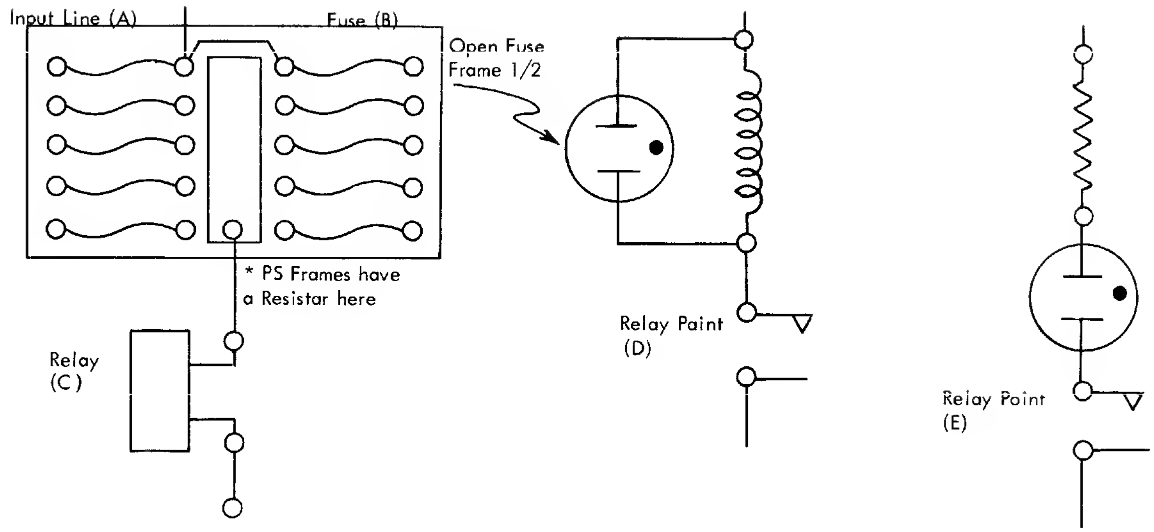


FIGURE 41-3. +15V FUSE MONITOR - WIRING SIDE



POWER FRAME 1						
Items	Unregulated L1	Unregulated L2	Unregulated L3	Regulated L1	Regulated L2	Regulated L3
Input Line (A)	9.25	9.25	9.25	9.24	9.24	9.24
Fuses (B)	725-732 PF1-33C	733-740 PF1-23C	741-748 PF1-23C	701-708 PF1-43C	709-716 PF1-43C	717-724 PF1-33C
Relay (C)	K2062 PF1-24C	K2063 PF1-24C	K2064 PF1-24C	K2065 PF1-34C	K2066 PF1-34C	K2067 PF1-34C
Relay Pt. (D)	K2062B PF1-24C	K2063B PF1-24C	K2064B PF1-24C	K2065B PF1-34C	K2066B PF1-34C	K2067B PF1-34C
Relay Pt. (E)	K244AU PDF-23A	K244AU PDF-23A	K244AU PDF-23A	K244AU PDF-23A	K244AU PDF-23A	K244AU PDF-23A
Fuse Chart	9.25	9.25	9.25	9.24	9.24	9.24

POWER FRAME 2						
Items	Unregulated L1	Unregulated L2	Unregulated L3	Regulated L1	Regulated L2	Regulated L3
Input Line (A)	9.27	9.27	9.27	9.26	9.26	9.26
Fuses (B)	825-832 PF2-33C	833-840 PF2-22C	841-888 PF2-22C	801-808 PF2-43C	809-816 PF2-43C	817-824 PF2-33C
Relay (C)	K2068 PF2-24C	K2069 PF2-24C	K2070 PF2-24C	K2071 PF2-34C	K2072 PF2-34C	K2073 PF2-34C
Relay Pt. (D)	K2068B PF2-24C	K2069B PF2-24C	K2070B PF2-24C	K2071B PF2-34C	K2072B PF2-34C	K2073B PF2-34C
Relay Pt. (E)	K245AU PDF-13A	K245AU PDF-13A	K245AU PDF-13A	K245AU PDF-13A	K245AU PDF-13A	K245AU PDF-13A
Fuse Chart	9.27	9.27	9.27	9.26	9.26	9.26

FIGURE 41-4A. FUSE CHART

POWER DISTRIBUTION FRAME						
Items	Motor Group A L1	L2	L3	Motor Group B L1	L2	L3
Fuses (B)	31-40 71-80 PDF-118	111-120 151-160 PDF-118	191-200 231-240 PDF-218	271-280 311-320 PDF-218	351-360 391-400 PDF-318	431-440 471-480 PDF-318
Relays (C)	K2048 PDF-33A	K2049 PDF-33A	K2050 PDF-33A	K2048 PDF-33A	K2049 PDF-33A	K2050 PDF-33A
Relay Pt. (E)	K2048B PDF-33A	K2049B PDF-33A	K2050B PDF-33A	K2048B PDF-33A	K2049B PDF-33A	K2050B PDF-33A
Fuse Charts 9.19	Sheet 1	Sheet 2	Sheet 3	Sheet 4	Sheet 5	Sheet 6

REGULATED AC						
Items	Motor Group A L1	L2	L3	Motor Group B L1	L2	L3
Fuses (B)	21-28 61-68 PDF-118	101-108 141-148 PDF-118	161-168 221-228 PDF-118	261-268 301-308 PDF-218	341-348 381-388 PDF-218	421-428 461-468 PDF-218
Relays (C)	K2051 PDF-33A	K2052 PDF-33A	K2053 PDF-33A	K2051 PDF-33A	K2052 PDF-33A	K2053 PDF-33A
Relay Pt. (E)	K2051B PDF-33A	K2052B PDF-33A	K2053B PDF-33A	K2051B PDF-33A	K2052B PDF-33A	K2053B PDF-33A
Fuse Charts 9.18	Sheet 1	Sheet 2	Sheet 3	Sheet 4	Sheet 5	Sheet 6

POWER SUPPLIES						
Pwr. Sup.	Fuses	No.	Resistor Rating	Loc.	Relay	Fuse Chart 9.17
-30	241-299 PDF-21B	2007	100 ohm 10W	PDF-13A	K2060 PDF-13A	Sheet 4
+15	161-219 PDF-21B				K2061 PDF-13A	Sheet 3
-250	401-459 PDF-31B	2004	1500 ohm 25W	PDF-23A	K2067 PDF-13A	Sheet 6
+220	541-599 PDF-11B	2005	1500 ohm 25W	PDF-13A	K2068 PDF-13A	Sheet 1
-100	321-379 PDF-31B	2006	500 ohm 10W	PDF-13A	K2059 PDF-13A	Sheet 5
+150	81-139 PDF-11B	2003	100 ohm 20W	PDF-23A	K2056 PDF-23A	Sheet 2
-130	20,60,100 PDF-11B	2002	700 ohm 20W	PDF-23A	K2066 PDF-23A	Sheet 1 & 2
+150 RY	180,220,260 300 PDF-21B 340,380,420 460 PDF-31B	2001	100 ohm 20W	PDF-23A	K2054 PDF-23A	Sheet 3, 4 5 & 6

FIGURE 41-4B. FUSE CHART

PF.42.00 AC POWER OFF

PF.42.01 Phase Protection Circuit

The supply line to the 704 is checked for correct phase relationship or loss of one phase by the phase protection circuit shown in Figure 42-1A. This circuit is mounted at the rear of the power distribution frame. If the voltages are all present and in correct relationship, the two relays pick up and hold. If any two phases are interchanged or if one or more phases is missing, one of the relays fails to pick, or drops. This prevents any power-up sequence, or gives a master power off, if power is already up.

Figure 42-1B indicates the three wye-connected phases, E_1, E_2, and E_3. The result of voltages between phases are represented by the dotted lines. Since K102 is connected directly between phases 2 and 3, current through it (I_{23}) is lagging by some angle, x, that is less than 90 degrees. (If the load was 100 percent inductive, this angle would be 90 degrees.) This current is sufficient to pick and hold relay K102. This would be true even if there were a phase reversal, and so K102 protects only against loss of phase 2 or 3.

Current through K101 is made up of two components, both smaller in magnitude than I_{23} because of the resistances in series. The first flows between phases 1 and 2 (I_{12}, Figure 42-1C) and lags E_{12} by some angle Y. This lagging angle is less than angle X in Figure 42-1B because of the resistance in series with the inductance of the relay coil. The second current component affecting K101 flows between one and three through one resistor, the relay coil and the capacitors. This current leads the voltage E_{13} by some angle Z. The two components add to give the current I_{K101}, which is enough to pick and hold the relay.

If any two phases are interchanged, the two components partially back each other rather than add. In Figure 42-1D, phases 2 and 3 have been exchanged. I_{12} still lags E_{12} by angle Y. I_{13} leads E_{13} by angle Z as before, but these two now partially oppose each other, giving a resultant current, I_{K101}, too small to hold the relay. Other possible phase reversals would produce similar results.

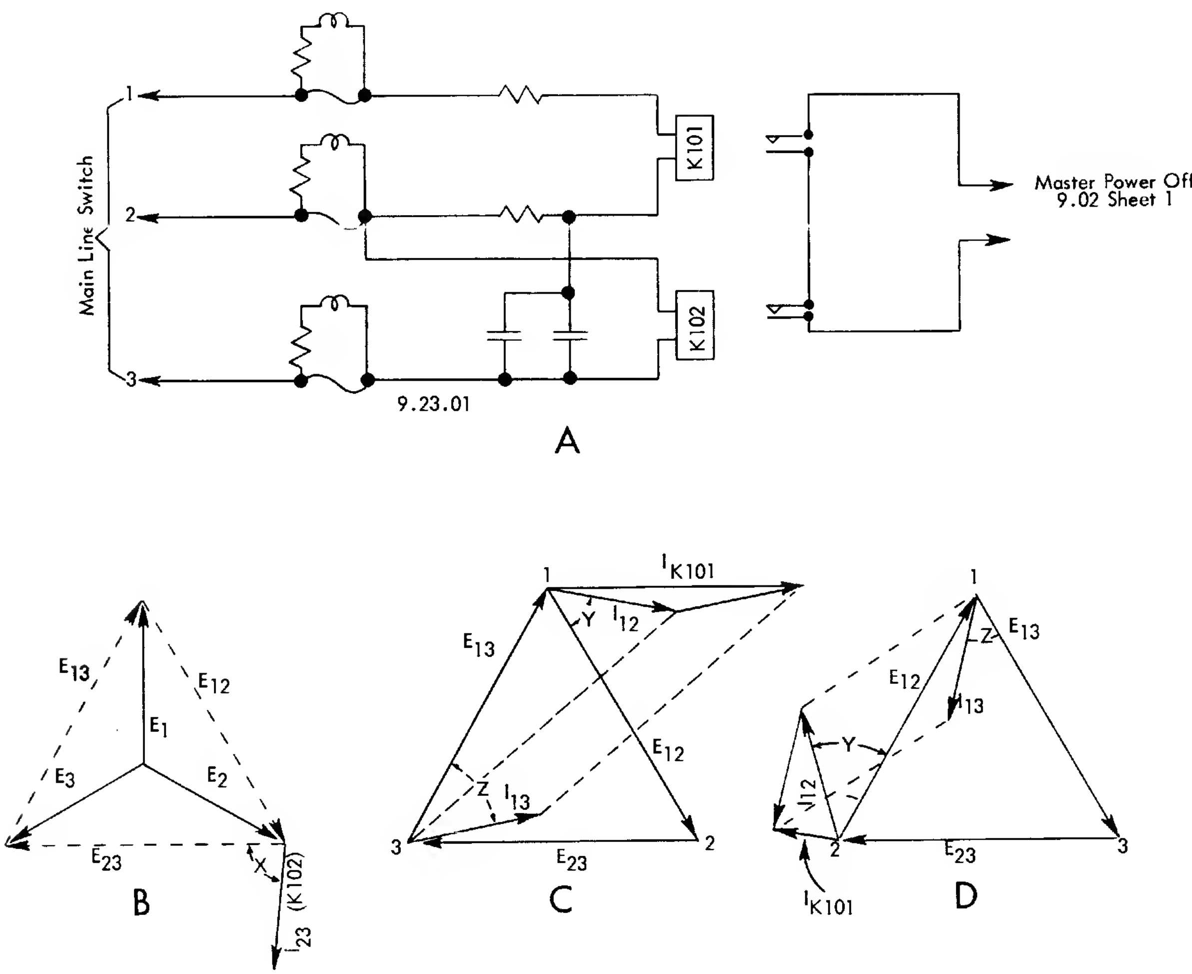


FIGURE 42-1. PHASE PROTECTION CIRCUIT

PF.42.02 Filament Regulator Warning Neon

The filament regulator warning neon comes on and a filament regulator warning is energized, if the high-low points in the high-low voltage sensing circuit of the AC line regulators are not open. This would indicate that the regulated filament voltage is not within limits. The sounding of this buzzer is under control of a switch at the rear of the door of the power distribution frame. If so desired, this switch can be left so that a high-low filament warning energizes contactor K232 instead of the buzzer and the points of the relay cause a normal off. In this event, a neon behind the door, near the relay and switch, indicates the reason for the normal off. The relay must be unlatched by hand before a power on sequence can start.

PF.42.03 Thermal Interlocks

Thermal interlocks are used in each of the frames of the calculating unit and in power frames 1 and 2 to detect excessive heating within the frames. A thermal interlock is a bimetallic device which opens its contacts at approximately 131 degrees F. These contacts are in series with the normal on-circuit and open to initiate a normal off-sequence if the temperature of any frame of the machine attains the operating temperature of the interlock (Systems Diagrams 9.23).

PF.42.04 Chassis Interlocks

Jumpers wired in connector plugs initiate a normal off-sequence if a voltage control, ripple suppressor or AC line-voltage regulator chassis is removed from a frame (Systems Diagrams 9.23).

PF.42.05 Blown AC Fuse Alarm Relay

This relay initiates a normal off-sequence if any AC fuse in the power supply is blown. When an AC fuse blows, the fuse plunger strikes the alarm bar to energize the blown-AC-fuse-alarm relay, which opens its points to cause a normal off-sequence (Systems Diagrams 9.23).

PF.42.06 Circuit Breakers

Circuit breakers, operated by current transformers, cause a normal off-sequence if the current, in any unregulated AC input line to an AC line voltage regulator, becomes excessive because of a line fault.

CB	Magnetic Element Shown On	Breaker Point Shown On.	Operate by Current Transformer No.	Used to Protect.	Physical Location in PDF.
207	9.06.01	9.23 (DC off)	208, 209	-130v rect	22A
209	9.11.01	9.23 (Norm off)	222, 223, 224	AC Line Reg	32A
210	9.04.03, 9.05.02	9.02-IB	219, 220, 221	Unregulated,	32A
	9.05.03, 9.07.02	(Master Pwr off)		fused AC	
	9.07.03				
	9.08.03, 9.09.02				
	9.12, 9.15, 9.18				
211	9.18	9.23 (Norm off)	None	CSU Reg AC	12A
308	9.03	9.23 (DC off)	310, 311	+150 Ry rect	32A
406	9.04.01	9.23 (DC off)	416, 417, 418	+150v rect	22A
505	9.05.01	9.23 (DC off)	506, 507	-250v rect	22A
703	9.07.01	9.23 (DC off)	703, 704, 705	-100v rect	12A
804	9.08.01	9.23 (DC off)	812, 813	+220v rect	22A
901	9.09.01	9.23 (DC off)	914, 915	+15v rect	12A
1002	9.10.01	9.23 (DC off)	1001, 1002	-30v rect	12A
2811	9.28	9.28	None	AC Outlets	41C

FIGURE 42-2. CIRCUIT BREAKER CROSS REFERENCE

PF.43.00 POWER SUPPLY TROUBLES

PF.43.01 Ripple Suppressors

There are several things that generally cause troubles in the ripple suppressors. If in scoping a line, the line voltage varies more than maximum ripple allowed, the ripple suppressor should be suspected. Maximum allowable ripple is given in section PF.15.17. The first step is to change the suspected ripple suppressor unit with another exactly alike and known to be in working order. This gives a definite indication of ripple suppressor trouble.

In the bad ripple suppressor drawer the 6AH6 amplifier is checked. This amplifies the ripple on the line so the suppressor can compensate the line voltage for the ripple content so the final output is a constant voltage. If the tube is weak or bad, the ripple is not compensated correctly. If changing the tube does not help, the complete unit can be looked over for bad or cold soldered connections or any other indications that you might see.

Another thing to check is the plate transformer for the output 5881 tubes. Under normal operation the hand can be placed on it. If it is running hot or giving out a bad odor, replace the transformer.

PF.43.02 Blown Fuses

Blown fuses is another common trouble. Some of them short and others do not indicate so the only sure method is a test with a meter for voltage drop with power on, or continuity with power off. Usually the fuses that blow are 0.8 amp fusatrons. Several that blow are fuses 846, 839, 736, 730, 828 and 844. These are in the unregulated bus of the ripple suppressors of different DC power supplies.

Another common trouble is the condenser C-A77 located on Systems Diagrams 9.04.03. This 20 ufd capacitor has a tendency to short and when it does it blows fuse 738 also located on Systems Diagrams 9.04.03. The short on the capacitor occurs either between pin 3 and 1 or pin 5 and 1 on the capacitor.

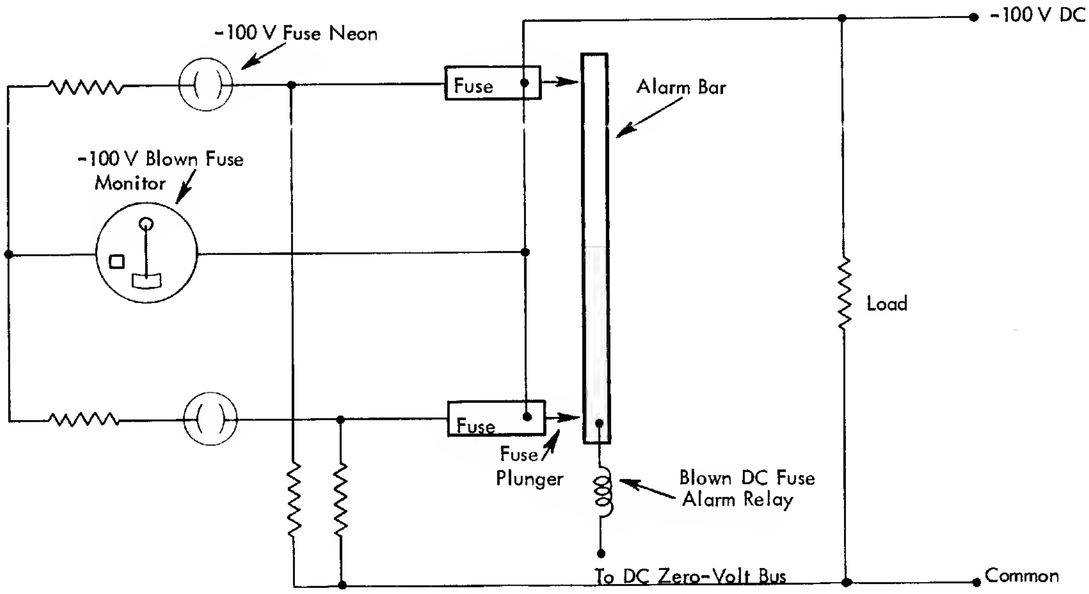


FIGURE 43-1. PORTION OF A-100 VOLT DC FUSE BLOCK

PF.43.03 Blower Motor Failure

If the blower motor nearest the hinge in MF3 stops, it probably causes a thermal interlock to open, picking an annunciator relay and giving a normal off. Here is one way to determine what may be the cause.

Since blowers run on unregulated AC and are fused, Systems Diagrams 9.00.00, sheet 3, gives a starting point. The fused AC goes to Systems Diagrams 9.29.00 (AC service in the main frame). Systems Diagrams 9.29.00, shows all the main frame service wiring and relay circuits (duplication of Systems Section 4.00.00). A typical blower-motor wiring circuit is shown on sheet 1, section 1B. On Systems Diagrams 9.29.00, sheet 3 is a diagram of the main frame panels showing fuse sections, filament transformer numbers and blower motor numbers. Motor number 2 is the dead one. Just to the right, near the page center is a small chart showing logical diagram numbers for blower fuses, and so on. Blower number 2 is fused by F78, F158 and F238 on page 9.19.00. The binder posts in the main frame and in the power distribution frame are also shown. On page 9.19.00 the fuses are on the right near the bottom of each of three panels. The trouble must be between these fuses and the blowers themselves if only one blower is stopped.

PF.43.04 General Overload, Unregulated, Fused AC

A general overload in the same circuit (Systems Diagrams 9.19.00) is over distributed so that it failed to blow, any fuse would trip CB 210 and give a master power off. At the top of each sheet of 9.19.00 is shown the primary of current transformers 219, 220 or 221. This is an example of a lack of cross reference in Systems Diagrams (there is apparently no way to find the secondaries of the transformer). However, follow any line off the page that goes to a power frame or the main frame and find the transformer duplicated, this time with the secondaries shown driving CB 210.

Obviously, if the blower motor circuit is overloaded, a power shut down of some kind is indicated, and page 9.02.00 (sequencing circuits) is the place to look for this. On Systems Diagrams 9.02.00, sheet 6, upper right corner, is a miscellaneous chart which indicates that CB 210, B3 is located in section 1B. There find the CB point in the circuit to drop all relays beginning with K202, giving a master power off.

The Circuit Breaker Reference Chart, Figure 43-1 should prove helpful in finding what circuits are protected by a particular breaker and where all associated circuits are located.

CB	Magnetic Element Shown on Page	Breaker Point Shown on Page	Operate by Current Transformer No.	Used to Protect	Physical Loc. in PDF
207	9.06.01	9.23 (DC Off)	208, 209	-130v rect.	22A
209	9.11.01	9.23 (Norm. Off)	222, 223, 224	AC Line Reg.	32A
210	9.04.03, 9.05.02	9.02 - 1B	219, 220, 221	Unregulated	32A
	9.05.03, 9.07.02	(Master Pwr. Off)		Fused AC	
	9.07.03 9.08.03, 9.09.02				
	9.14, 9.15, 9.18				
211	9.18	9.23 (Norm. Off)	None	CSU Reg. AC	12A
308	9.03	9.23 (DC Off)	310, 311	+150 RY rect.	32A
406	9.04.01	9.23 (DC Off)	416, 417, 418	+150v rect.	22A
505	9.05.01	9.23 (DC Off)	506, 507	-250v rect.	22A
703	9.07.01	9.23 (DC Off)	703, 704, 705	-100v rect.	12A
804	9.08.01	9.23 (DC Off)	812, 813	+220v rect.	22A
901	9.09.01	9.23 (DC Off)	914, 915	+15v rect.	12A
1002	9.10.01	9.23 (DC Off)	1001, 1002	-30v rect.	12A
2811	9.28	9.28	None	AC Outlets	41C

FIGURE 43-2. CIRCUIT BREAKER REFERENCE CHART

PF.51.00 INTRODUCTION

Power is supplied to the 704 Data Processing System from a 208-volt, 3-phase, 4-wire, wye-connected, 60-cycle power source.

The standard calculator power drain is 90.8 KVA (including 10.6 KVA for the power supply) under normal load. Voltages appearing on the 3-phase input lines must be held to within plus or minus 2 percent of each other and also must be held to plus or minus 8 percent about a mean input value of 208 volts. The calculator load is so distributed that currents in the 3-phase lines are balanced to within 10 percent of each other.

The power supply output consists of the following three voltages: (1) unregulated, single phase and wye connected 3-phase, 120/208 AC voltages for the motors in the calculating units and the power supply, (2) regulated, 120 volt AC voltage for the 3-phase filament transformers, distributed among all three phases, and (3) eight regulated and filtered DC voltages.

The power supply system is contained in three frames: power frame 1 (736), power frame 2 (741), and a power distribution frame (746). Power frames one and two contain all the individual AC line voltage regulators, DC rectifier voltage supplies, associated ripple suppressors, voltage control units, and operational timing apparatus. The power distribution frame contains the equipment for control and distribution of AC and DC power throughout the calculator, including the majority of the power supply: sequencing circuit components, fast discharge resistors, surge limiting resistors, all meters and monitor relays, termination of cables connecting the power supply to the AC power source and the other units of the calculator, terminations of cables connecting the distribution frame to the two power frames and indicating fuses for all voltages. Associated blown fuse neons for the -100 and -250v supplies and circuit breakers for the AC inputs to the rectifiers, regulators, and motors are also contained in the power distribution frame. The control panel is mounted on the front of the power distribution frame door. From the control panel the equipment is turned on and off, and various power supply circuits are metered. The major components of the power supply system are shown on page 9.00.00 in 704 Systems Vol. 4. The location of various parts of the power supplies are shown on Figures 51-1 to 51-6.

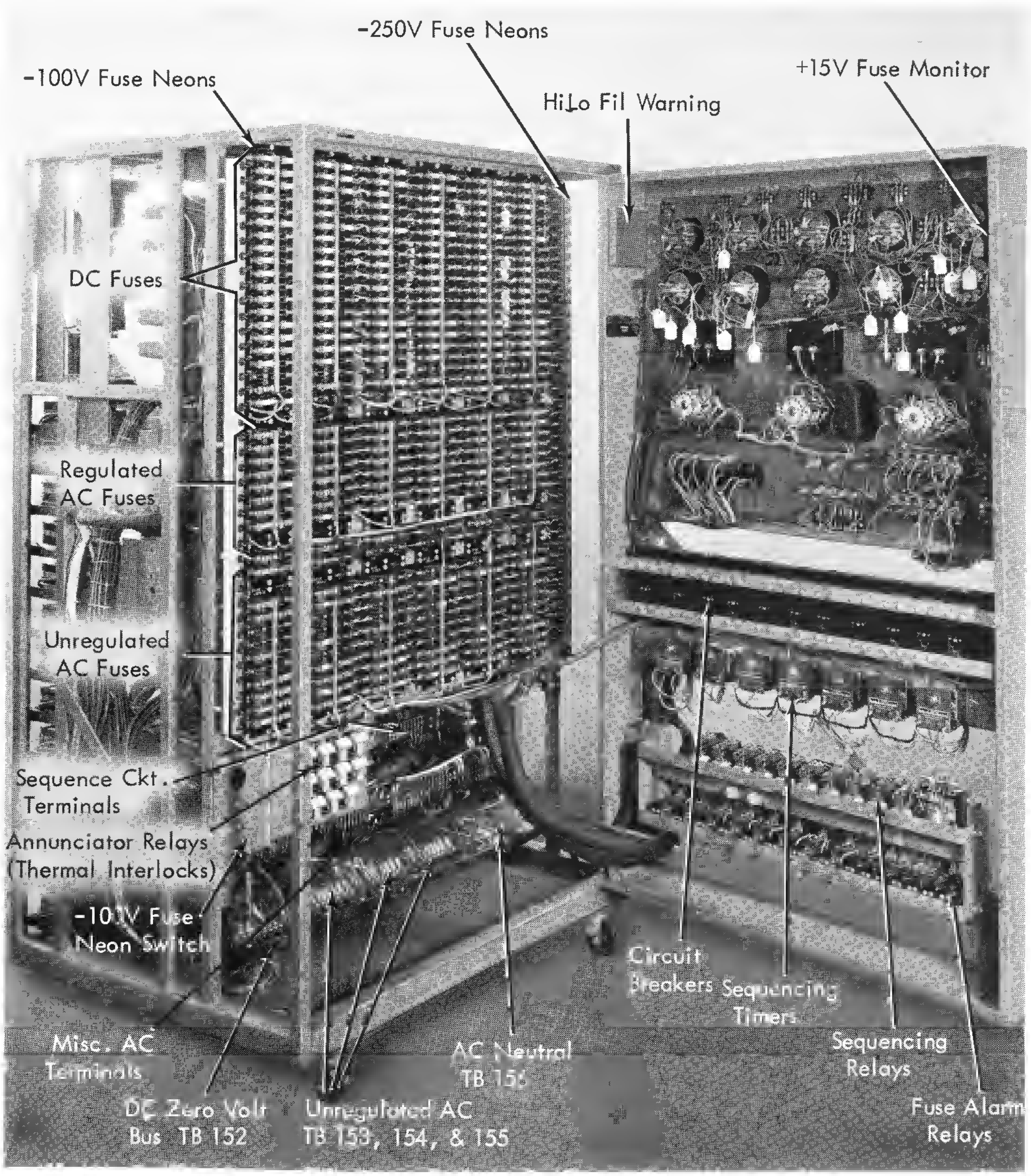


FIGURE 51-1. IBM 746 POWER DISTRIBUTION FRAME (INSIDE VIEW)

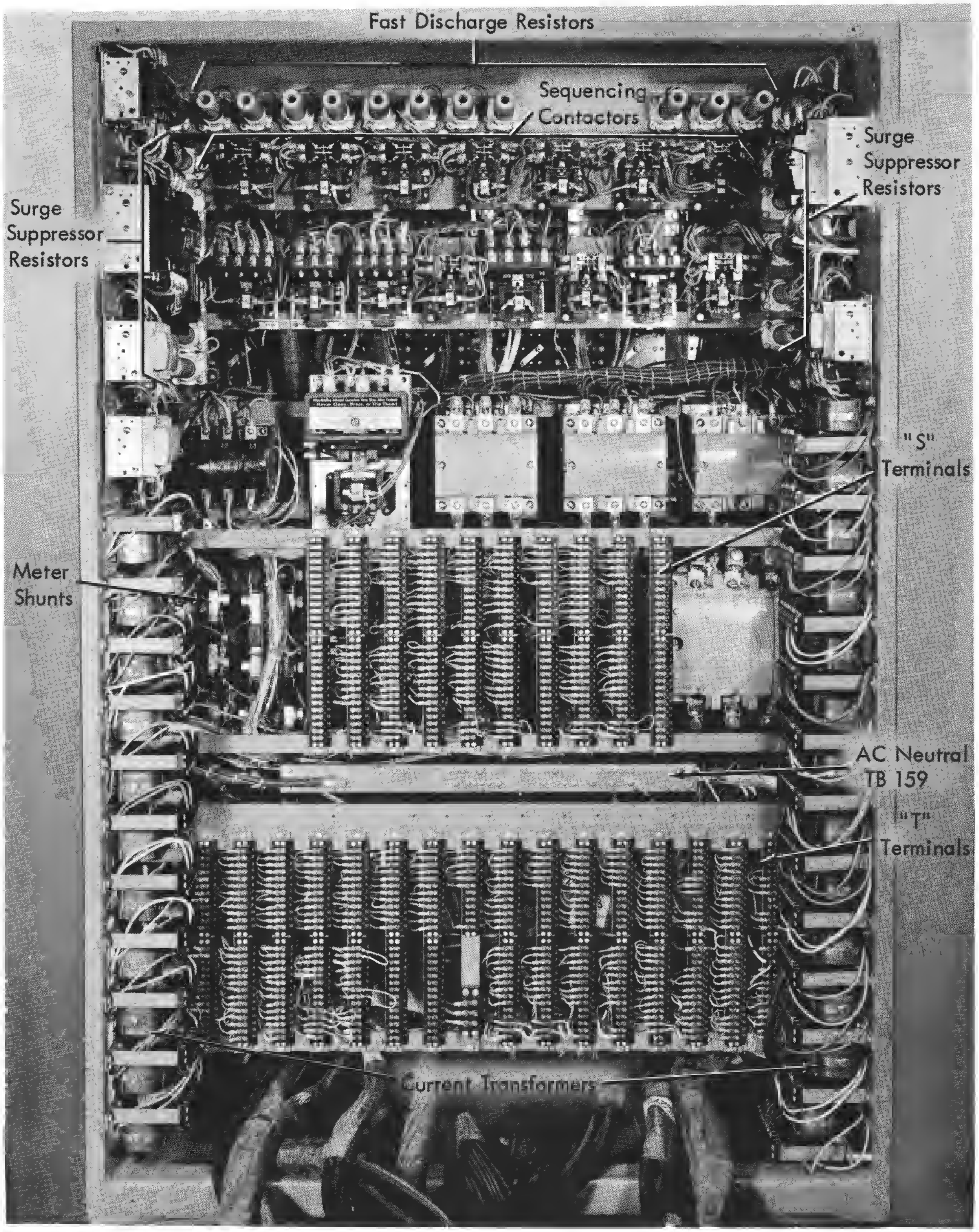


FIGURE 51-2. IBM 746 POWER DISTRIBUTION FRAME (REAR VIEW)

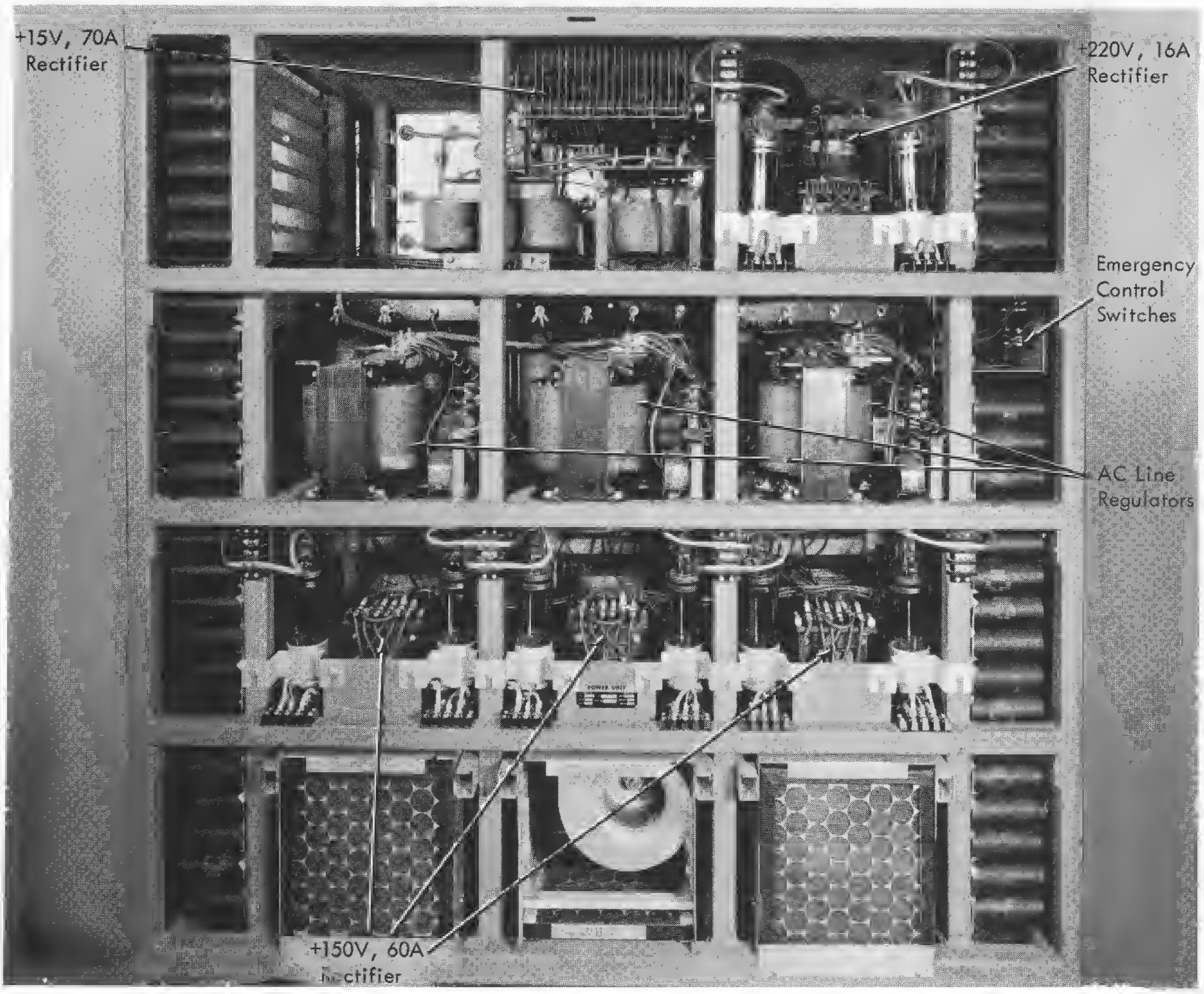


FIGURE 51-3. IBM 736 (POWER FRAME 1) (FRONT VIEW)

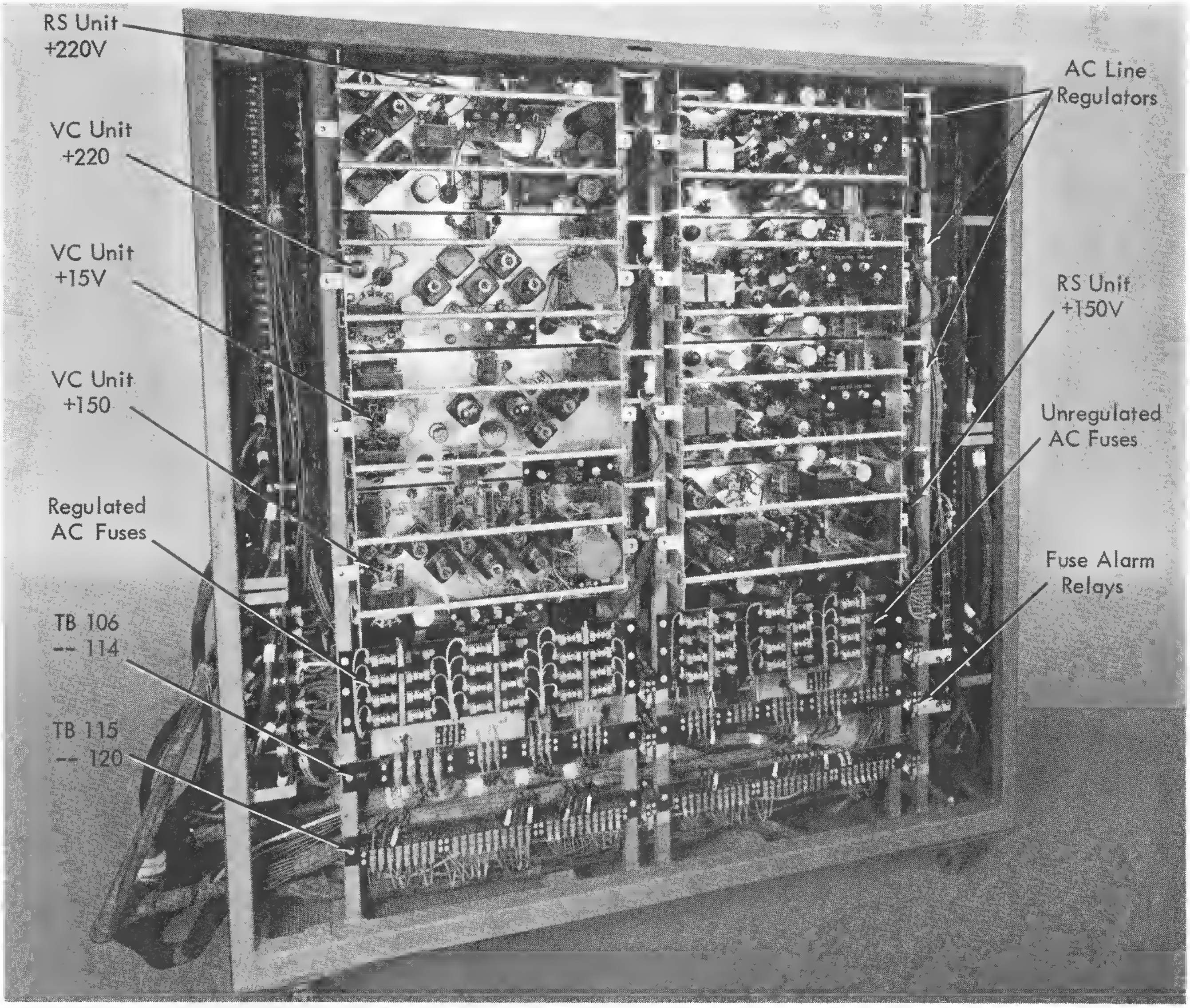


FIGURE 51-4. IBM 736 (POWER FRAME 1) (REAR VIEW)

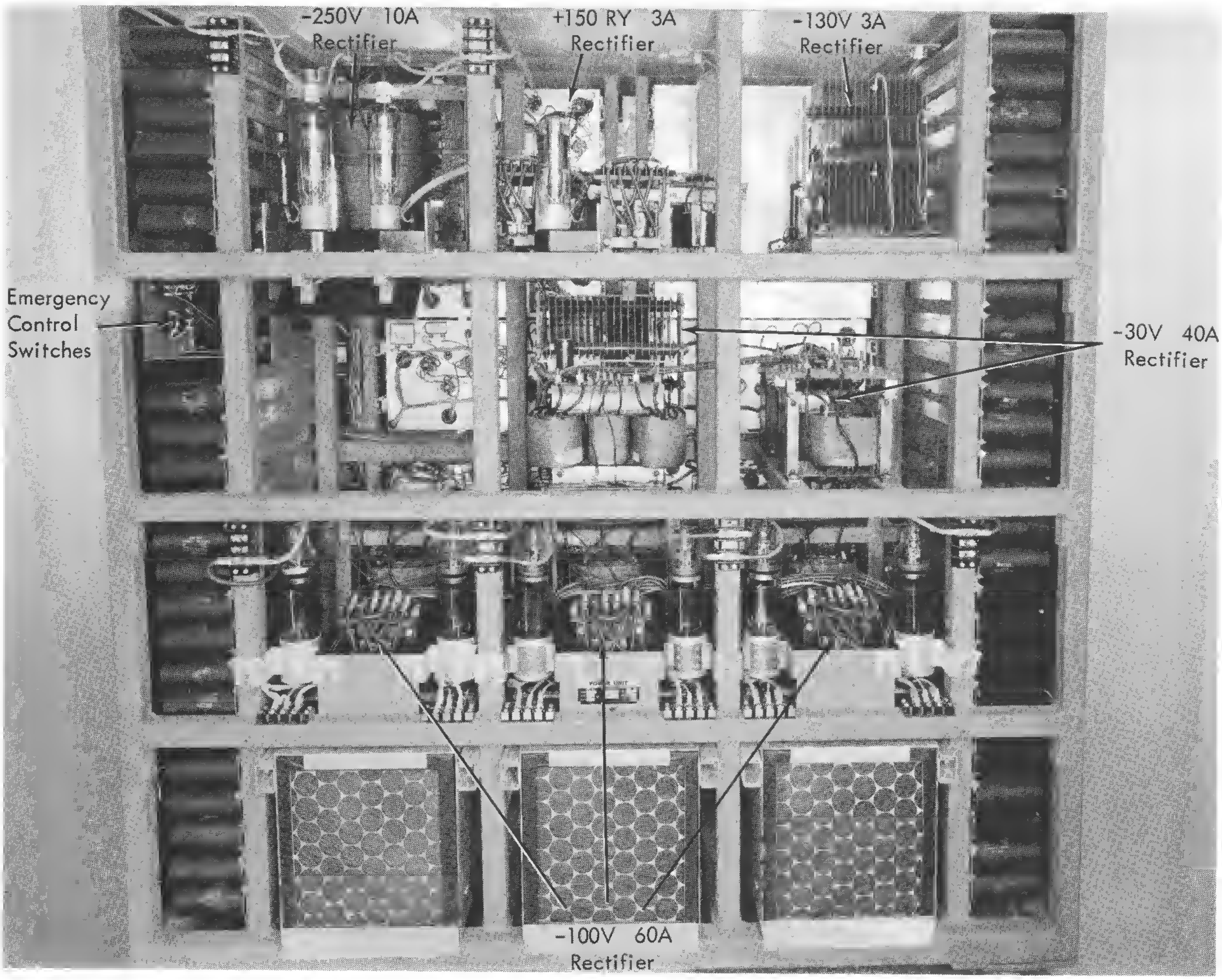


FIGURE 51-5. IBM 741 (POWER FRAME 2) (FRONT VIEW)

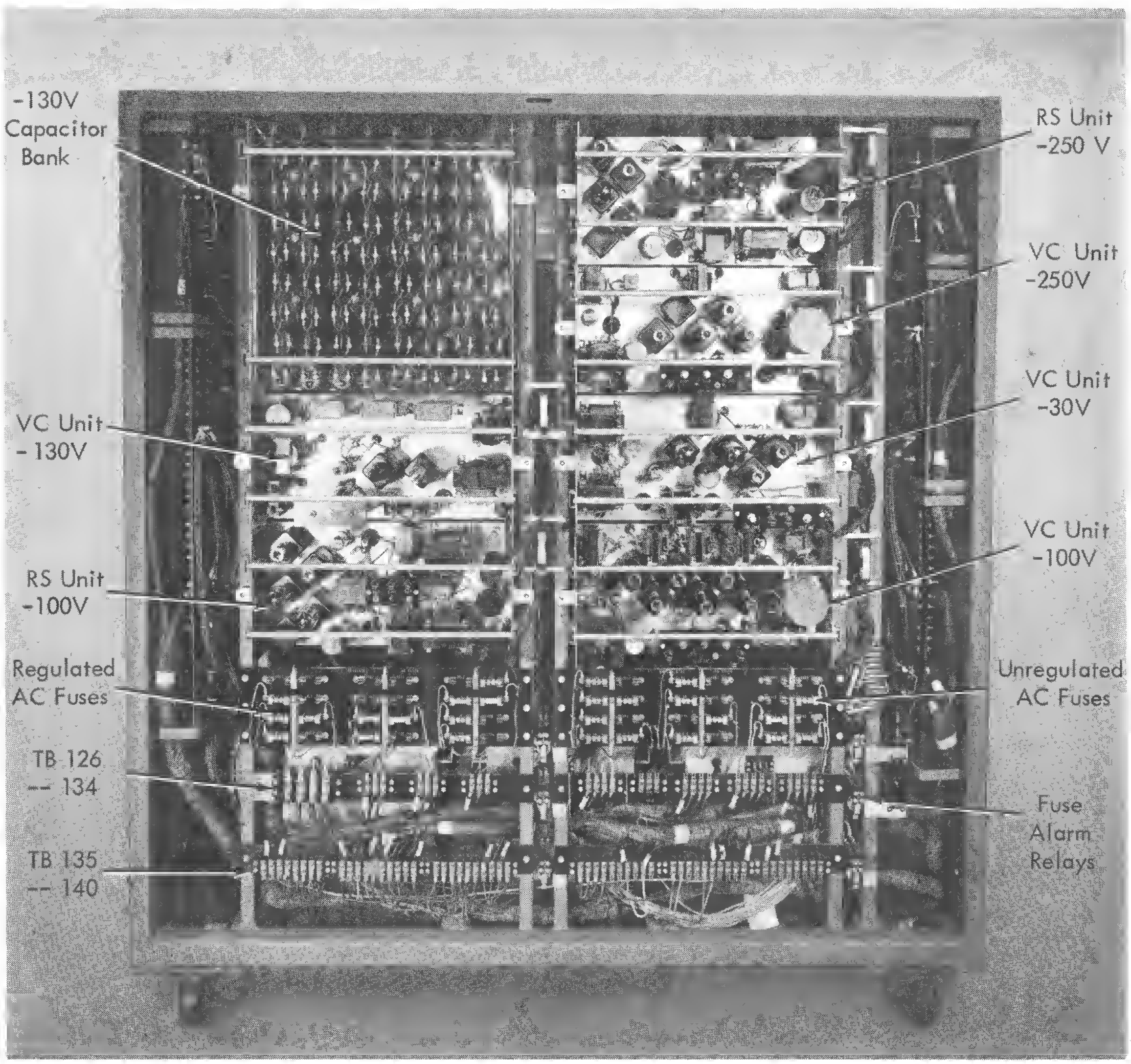


FIGURE 51-6. IBM 741 (POWER FRAME 2) (REAR VIEW)

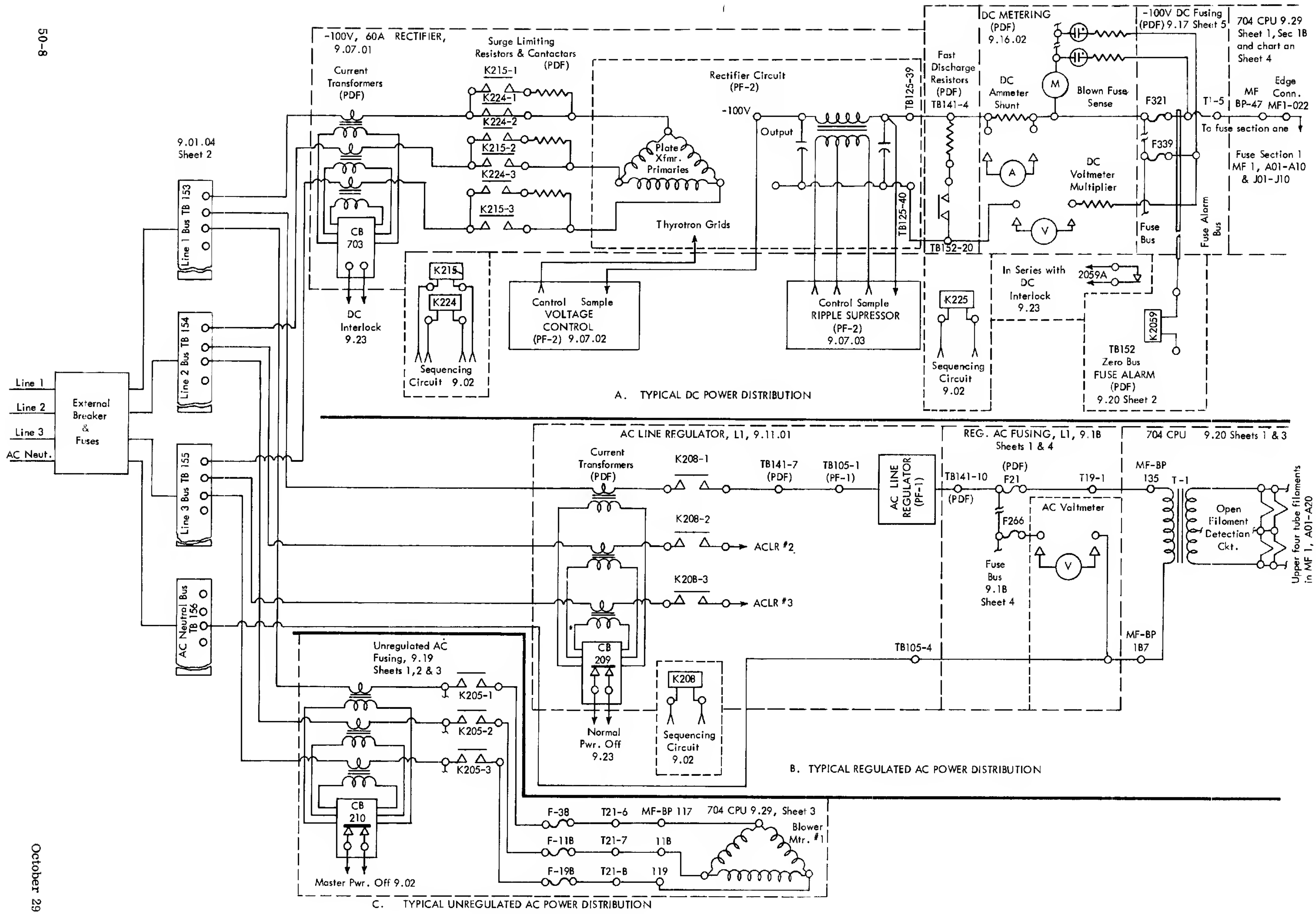


FIGURE 51-7. TYPICAL POWER DISTRIBUTION CIRCUITS

PF. 52. 00 NUMBERING

PF. 52. 01 Chassis Numbering

Systems diagrams 9. 01. 01, 9. 01. 02 and 9. 01. 03 show how each power supply frame is divided into coordinates. The chassis and components are located by means of this coordinate system.

The first number of the coordinate location indicates the left to right section location. The second number indicates the top to bottom section location, and the letter indicates the front to back section location. With the component located within the section, it can be identified by the stenciled component numbers.

PF. 52. 02 Component Numbering

Component numbers are three or four digit numbers for the non-interchangeable components. For the interchangeable components, a two digit number prefaced by one or two letters is used. Three or four digit component numbers are used for components in the rectifier chassis, since these are not ordinarily interchanged. Pluggable units which can be used in only one voltage control chassis also have three or four digit numbers. The first digit of a three digit component number or the first two digits of a four digit component number indicates the DC supply to which the chassis or component belongs. The last two digits of the component number indicates whether the component or pluggable unit belongs in the rectifier chassis, ripple suppressor, or voltage control chassis. For interchangeable components the letter is used in place of the first one or two digits to indicate the type of chassis in the voltage group within which that component is interchangeable. For components in a voltage controlled chassis, two letters are used if the component is interchangeable within two voltage groups. All ripple suppressor chassis are interchangeable and all AC line-voltage regulator chassis are interchangeable as indicated by the letters A and B respectively. See Figure 52-1 for a numbering chart.

CHASSIS		COMPONENT NUMBER		
		1st DIGITS OR LETTER		LAST TWO DIGITS
RIPPLE SUPPRESSOR			A	75-99
AC LINE VOLTAGE REGULATOR			B	01-20
VOLTAGE CONTROL CHASSIS	+ 15v	9	C	21-74
	- 30v	10		
	+220v	8	D	
	-250v	5		
	-160v*	6		
	+150v 60A	4	E	
	-100v	7		
	-130v**	2	-	
RECTIFIER CHASSIS	-130v**	2		01-20
	+150v 3A	3		
	+150v 60A	4		
	-250v	5		
	-160v*	6		
	-100v	7		
	+220v	8		
	+ 15v	9		
	- 30v	10		

* 738 Only
** 737 Only

FIGURE 52-1. POWER SUPPLY COMPONENT NUMBERING

PF. 53. 00 SEQUENCING OF POWER

PF. 53. 01 Application of Power

The components and units of the power supplied to receive AC power is placed in three general groups: (1) motors, (in both the calculating units and the power supply), (2) AC voltage regular units, and (3) main rectifier elements of individual AC supplies.

Motors in the machine are connected in two groups, A and B, and power is applied to each group in turn. Since each group draws a starting current of about 250 amps, both groups cannot be energized at the same time. With a full complement of drums, the starting current maybe as high as 400 amps.

Motor group A is the first to receive power. The motors in this group are allowed 10 seconds to reach running speed before power is applied to motor group B. After an additional 10 seconds to allow the motors in group B to attain running speed, power is supplied to three AC voltage regulator units, one for each of the three phase lines. These units are the source of regulating alternating voltage for calculator filaments. The time allowed for the filaments to reach operating temperature is 1. 25 minutes.

After the 1. 25 minutes for a filament warm-up have expired, the main rectifying elements of the individual DC supplies receive AC power. An exception to this is the +150v 3-amp supply, which does not receive AC power until much later in the sequence.

PF. 53. 02 Thyratron Control

The procedure of energizing eight voltages in five steps is followed to maintain the back voltage across the crystal diodes used in the machine at or below the maximum allowable value.

Since all of the individual supplies are capacitor input filters with capacities ranging up in the tens of thousands of microfarads, the output voltages of the individual supply must not be allowed to rise to their rated values instantaneously after applying full plate voltage to the rectifier circuit. This would result in a peak charging current far in excess of the rating of the rectifier tubes. The supplies which constitute exceptions to this are the +150v, 3 amp, -30v, +15v, and -130v supplies. The current and ripple specifications for the +150v, three-amp supply are such that a comparitively small amount of filtered capacity is required. The DC output voltage is allowed to appear immediately upon application of AC power to the plate transformer without exceeding the peak current rating of the rectifier tubes. Although the -130v, +15v, and -30v supplies are comparitively high current supplies and each has a large amount of filter capacity, DC output voltages can be allowed to come up immediately. Initial peak charging current is limited here by the high impedance of the selenium rectifiers and is not large enough to damage the rectifiers. When AC power is supplied to the main rectifying elements of all the DC supplies, -30v and +15v supplies obtain rated output as soon as the surge-limiting resistors are shorted out and the fast-discharge resistors are removed. The ripple suppressors in voltage control units receive regulated AC at the time that an AC voltage is supplied to the AC-line voltage regulators. However, the AC power for the +150v, 3-amp and -130v, 3-amp supplies are not applied until all the voltages up through group 4 attain rated values, since DC voltage appears at nearly the same instant that AC voltage is applied. The outputs of the other supplies are gradually and sequentially increased to their rated values. It requires 30 seconds for each group to arrive at rated output voltage. The voltages within a group cannot begin to rise to rated values until the timer in the preceeding group has completed its timing cycle.

PF. 53. 03 Voltage Monitors

Each group is monitored at the end of the 30-second interval allowed for the voltages within a group to rise to nominal values. If any particular voltage is not within the required range, the voltage monitor contacts operate a relay to start a DC-off sequence.

PF. 53. 04 Sequence

Power On (K201). Relay energized by pushing the power on key up as long as the key is depressed.

Panic Off (K202). Relay that controls power in machine. If it is de-energized, blowers are stopped and power is dropped immediately.

Normal Off (K204). Relay points control sequencing off of power leaves blowers run until heat is dissipated.

DC Off (K203). Relay points that control the sequencing off of DC power but leave AC on the machine.

Alarm Gong (K274). Points control the alarm gong so that anytime power goes off the bell will ring.

Motor Group A (K205). Points controlling half the motors and blowers in the machine.

Motor Timer (TD201). The load of starting all motors at once is too great so a timer is added to split the load in half.

Motor Group B (K206). Points controlling the other half of the motors and blowers in the machine.

Motor Timer (TD202). A timer delay to be sure all blowers in the machine are running before sequencing is started.

Sequence Relay (K207). Points control applying power to AC Line Regulators and for further control of sequencing.

AC Line Regulators (K208). Points energize the regulator to apply regulated 208v to all the DC supplies.

Sequence Relay (K209). Points are used to control relays which put power to DC supplies.

Filament Delay (TD203). A delay in sequence until the AC Line Regulators are up and have the filaments of all tubes in machine heated.

Filament Warning (K210). Points used to connect power to DC supplies.

Power Relays (K212, K213, K214, K215, K216, K217). Points used to energize DC supply rectifiers and transformer primaries. As power is put on these supplies the DC supplies start coming up to rated value.

Surge Limiting Resistors (K220, K222, K223, K224, K226, K227). Points remove resistors across inputs of various supplies. When power is suddenly applied to the plate transformer of a rectifier, a surge of current is developed in the primary winding of the transformer which could be excessive and cause damage to the winding. To limit the surge current, resistors are placed in series with the plate-transformer primary before applying current to the primary winding. These surge limiting resistors are shorted out 2 seconds after applying AC power to the transformer. The two-second delay allows sufficient time for them to dissipate the surge power.

Fast Discharge Resistors (K221, K221A, K225, K228). Points remove resistors from across the output capacitor of DC supplies. After the surge limiting resistors are shorted out, fast discharge resistors are removed from across the output of each supply. These fast discharge resistors are connected across the output condensor banks when power is removed from a supply to discharge the voltage rapidly. After removing the fast discharge resistors from all of the supplies, the monitor reset coils are energized and voltage and bias fuse monitor circuits are made operative.

The output voltages of the supplies are not allowed to appear instantly or simultaneously with the application of AC power to the rectifier plates. Eight voltages in five sequential groups are delivered to the calculator. The voltages are grouped as follows: group 1 (+15 and -30 volts), group 2 (-100 volts), group 3 (+220 volts), group 4 (-250 volts), and group 5 (+150 volts, 60 amps; +150 volts, 3 amps; -130 volts, 3 amps; -100C).

Monitor Reset. As the power supplies build up the monitor reset relays are energized in the same sequence. These reset the monitors so any off limits of any DC supply will trip off the power relays K231, K733, K834, K535, K438, K236, K240, and K242.

Voltage Neons. As each power supply builds up the neons light to show the power is up and within limits.

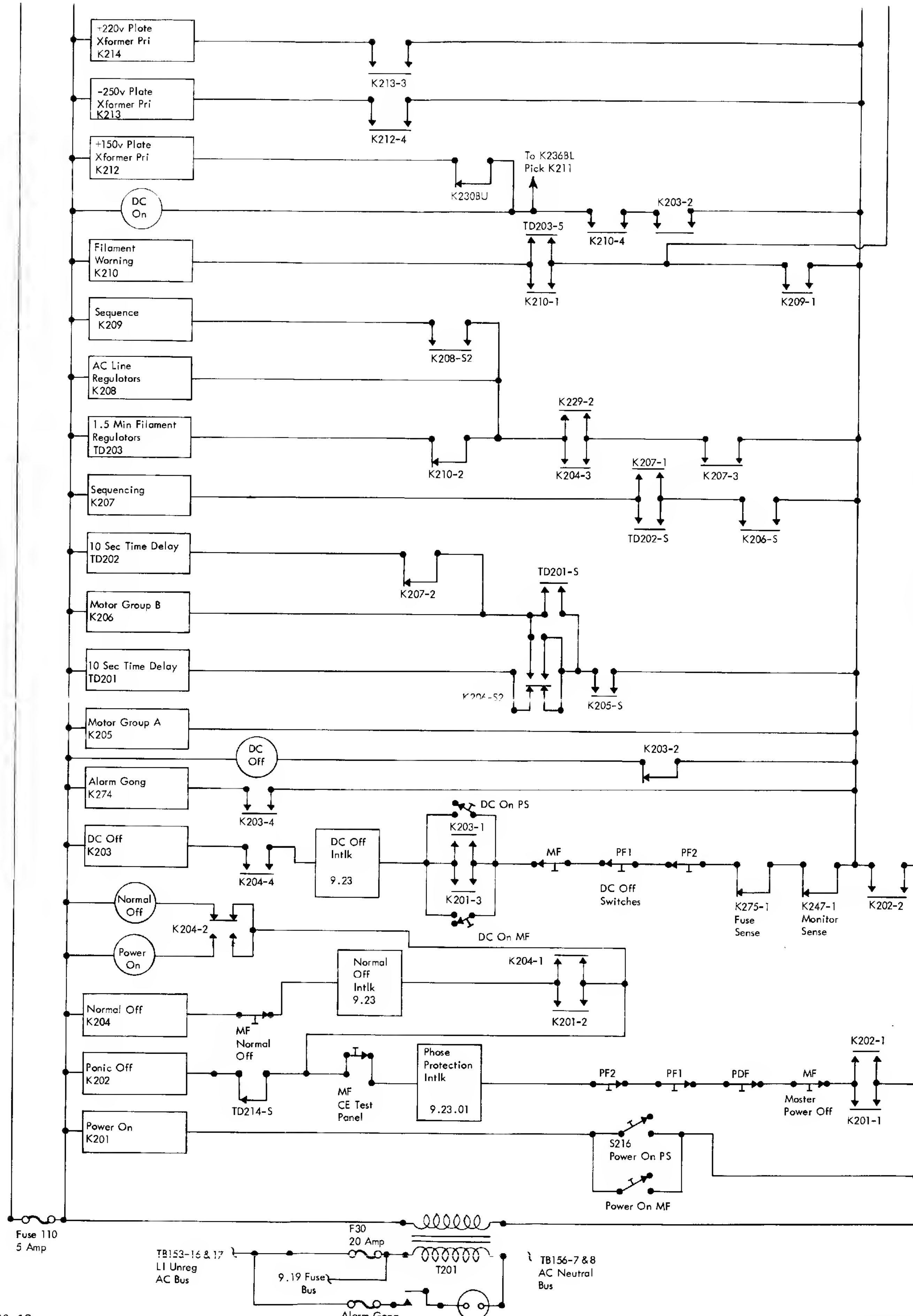


FIGURE 53-1A. RELAY SEQUENCE OF POWER

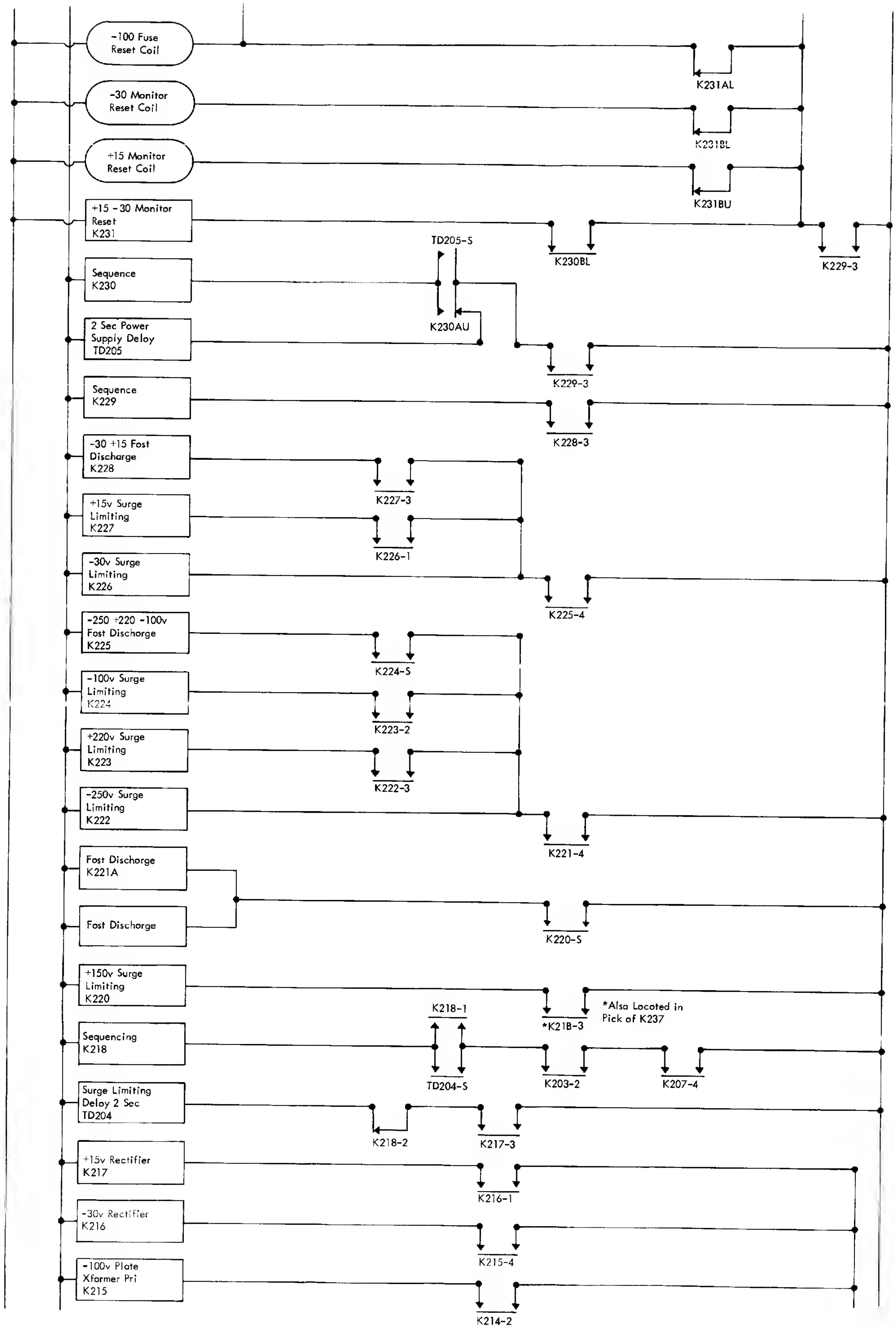


FIGURE 53-1B. RELAY SEQUENCE OF POWER

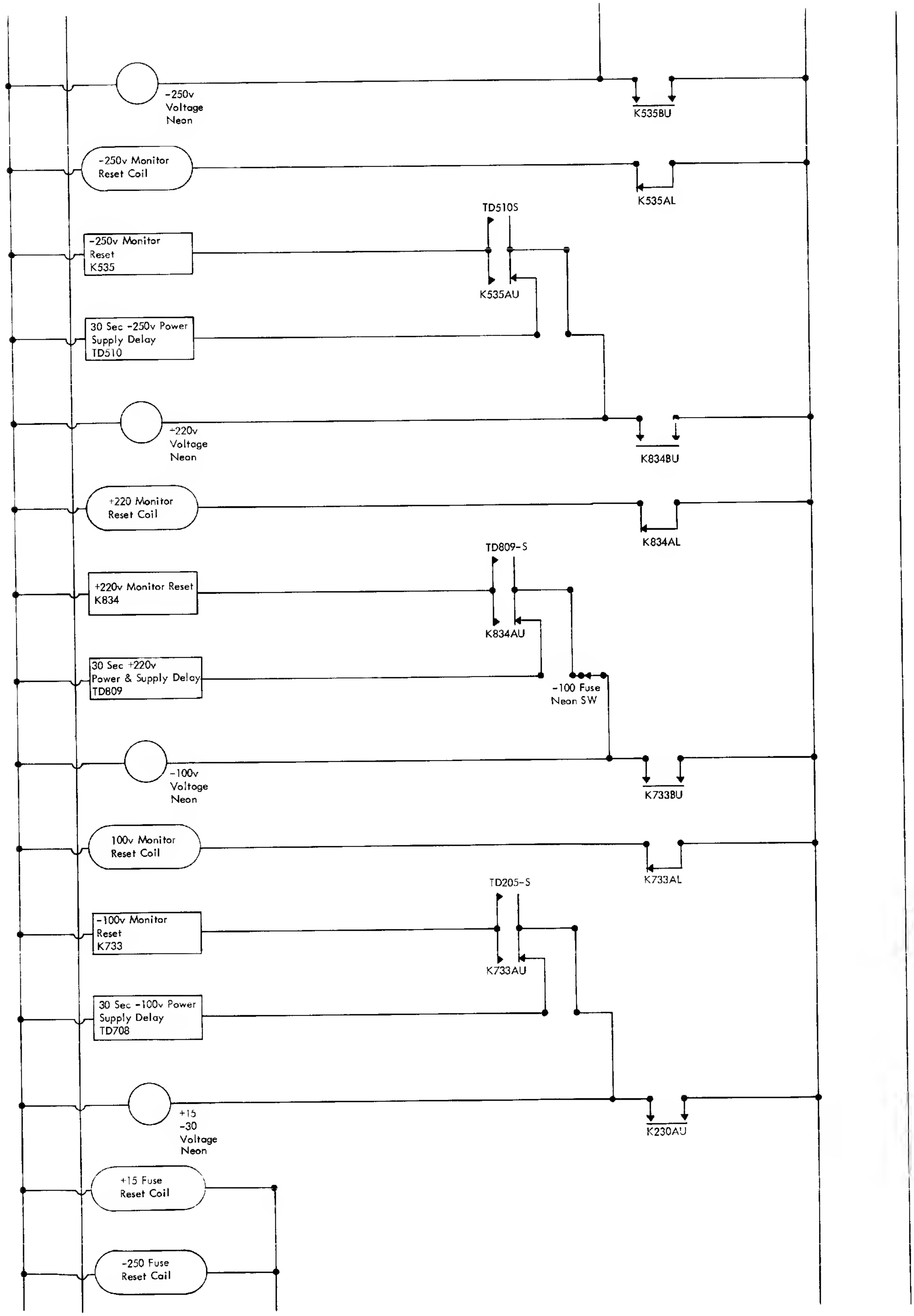


FIGURE 53-1C. RELAY SEQUENCING OF POWER

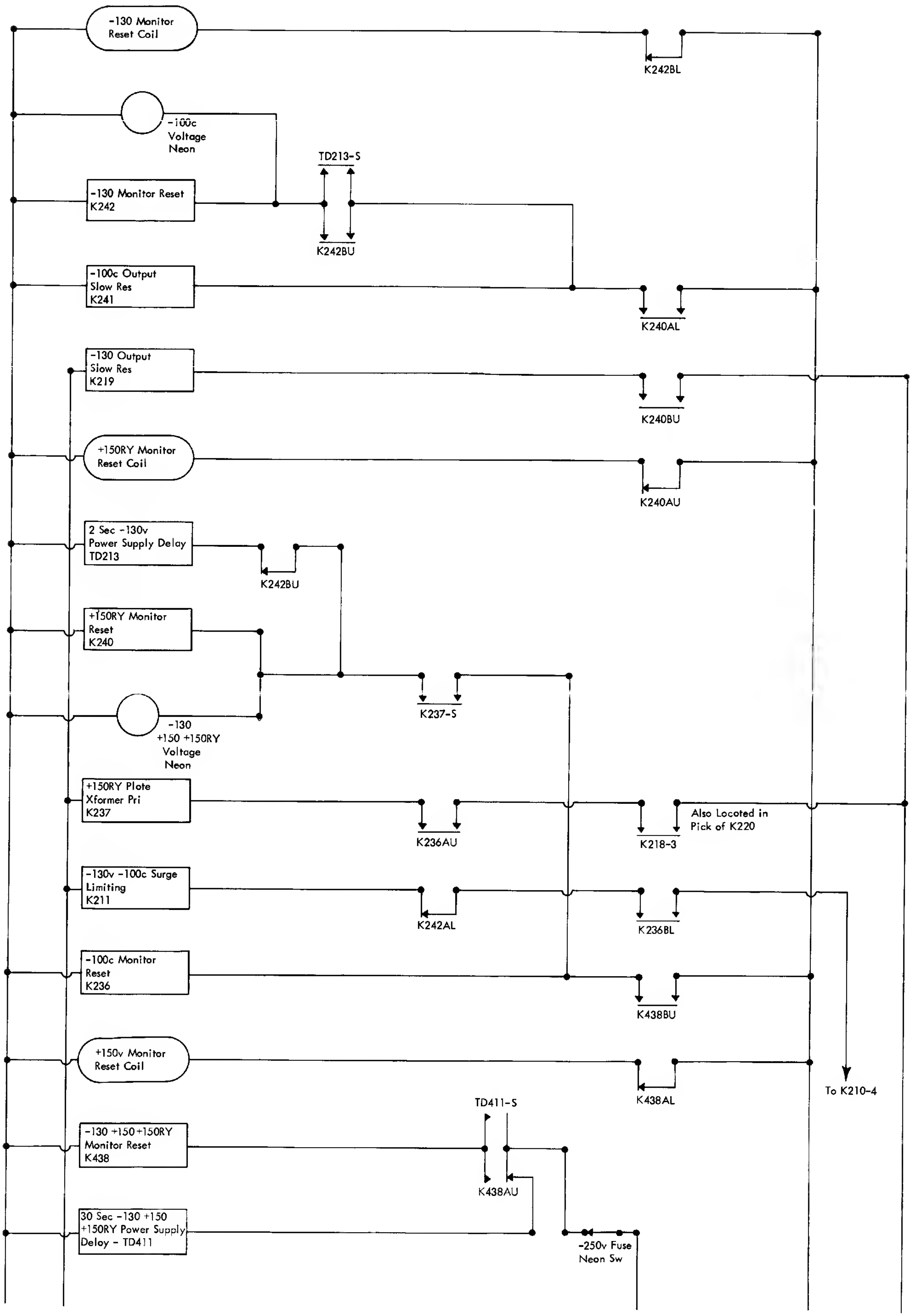
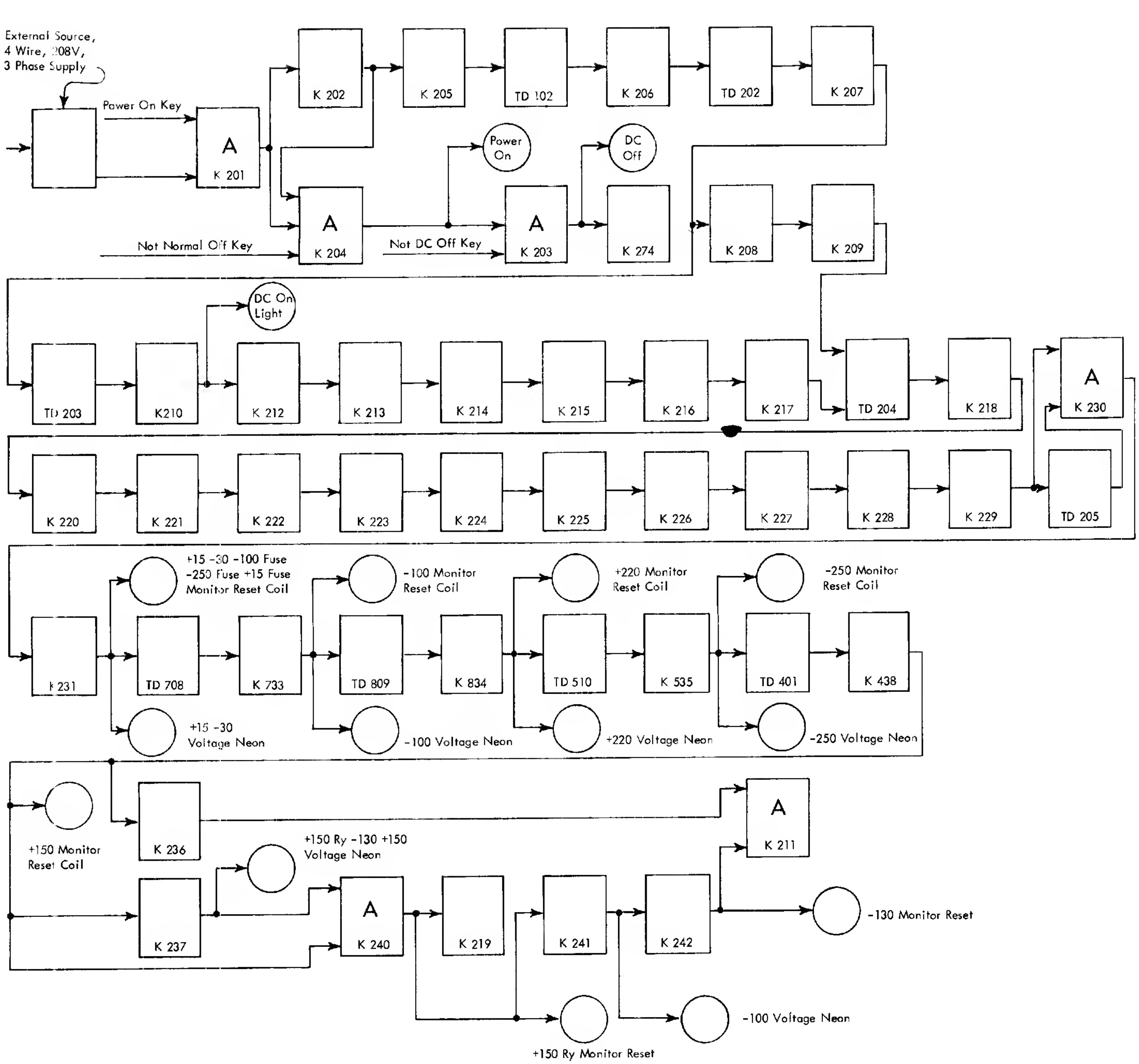


FIGURE 53-1D. RELAY SEQUENCE OF POWER



K201	Power on Relay
K202	Panic Off
K203	DC Off Only
K204	Normal Off
K205	Motor Group A
K206	Motor Group B
K207	To Sequence Up Power to Line Reg
K208	AC Line Reg
K209	Sequence Relay
K210	Filament Warning Regulator
K212	Relay to Energize 150v 60A Plate X Former Primary
K213	Relay to Energize - 250 Plate X Former Primary
K214	Relay to Energize + 220 Plate X Former Primary
K215	Relay to Energize - 100 Plate X Former Primary
K216	Relay to Energize - 30 Rectifier
K217	Relay to Energize + 15 Rectifier
K218	Sequencing Relay
K219	- 130 Removes Slow Resistor from Output
K220	+ 150 Removes Surge Limiting Resistors to Put Supply on Line
K221	Fast Disc Resistors Across Output Cap Removed on - 130 + 150 & - 100c
K222	- 250 Removes Surge Limiting Resistors
K223	+ 220 Removes Surge Limiting Resistors
K224	- 100 Removes Surge Limiting Resistors
K225	Removes Fast Disc Res Across Output of - 250 + 220 - 100
K226	- 30 Removes Surge Limiting Resistors
K227	+ 15 Removes Surge Limiting Resistors
K228	Removes Fast Disc Resistors on Output of - 30 + 15
K229	Sequencing Relay
K230	Sequence Relay
K231	+ 15 - 30 Monitor Reset
K236	- 100c Monitor Reset
K237	+ 150RY Plate X Former
K240	+ 150RY Monitor Reset
K241	- 100c Removes Slow Resistors from Output
K242	- 130 Monitor Reset
K438	+ 150 Monitor Reset
K535	- 250 Monitor Reset
K834	+ 220 Monitor Reset
TD201	10 Sec Delay for Motor Group A to Start
TD 202	10 Sec Time Delay for Motor Group B to Start
TD203	1.5 Min Delay for Line Reg to be Up Before Energizer Warning Reg
TD204	2 Sec Delay to Remove Surge Limitnig Resistors
TD205	2 Sec Time for + 15 - 30 Supply to Build Up
TD20	30 Sec Time for + 150 to Build Up
TD501	30 Sec Time for - 220v to Build Up
TD708	30 Sec Time for - 100v Supply to Build Up
TD809	30 Sec Time for + 220 to Build Up

FIGURE 53-2. LOGIC SEQUENCE OF POWER

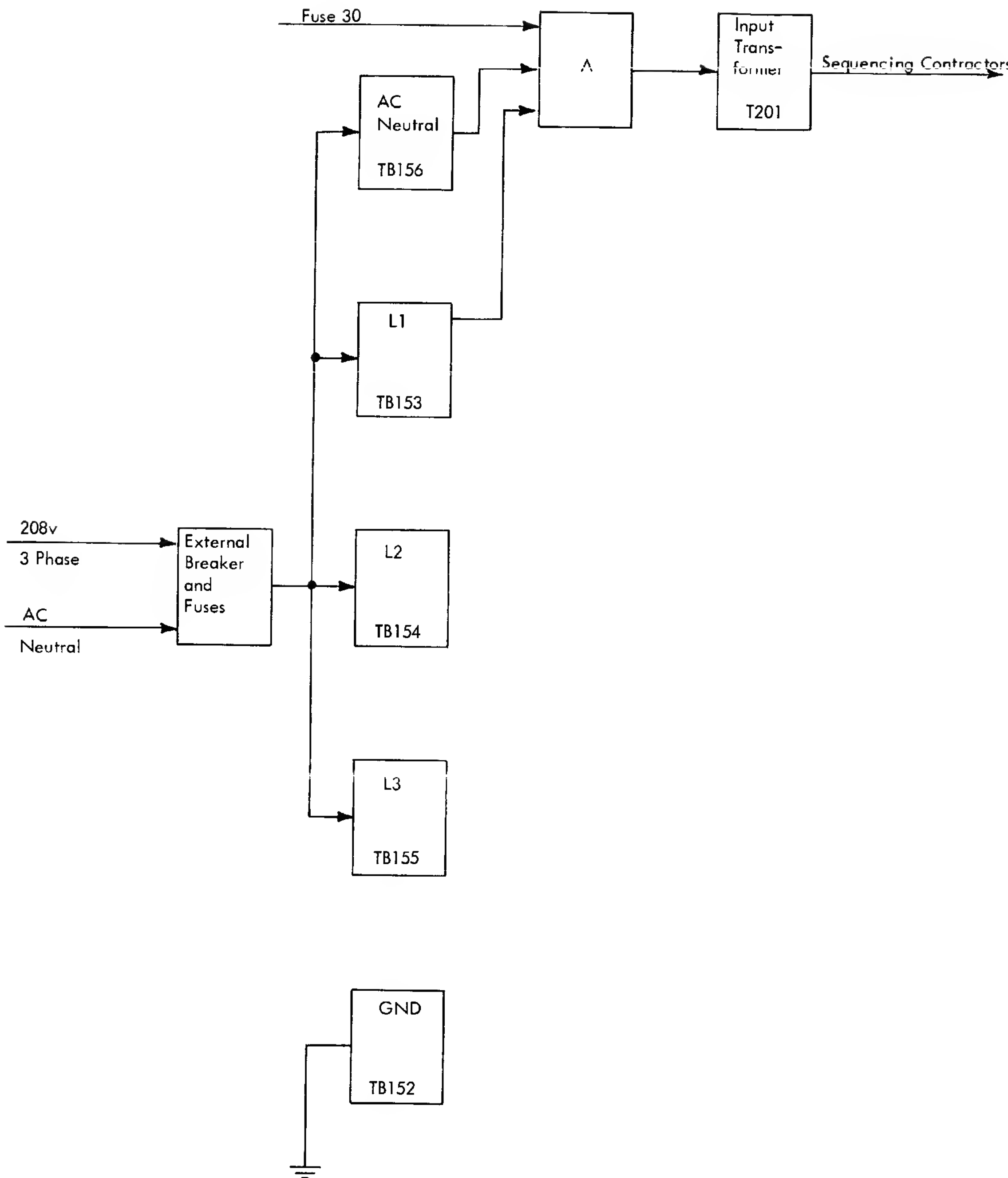


FIGURE 53-3A. AND/OR SEQUENCE OF POWER

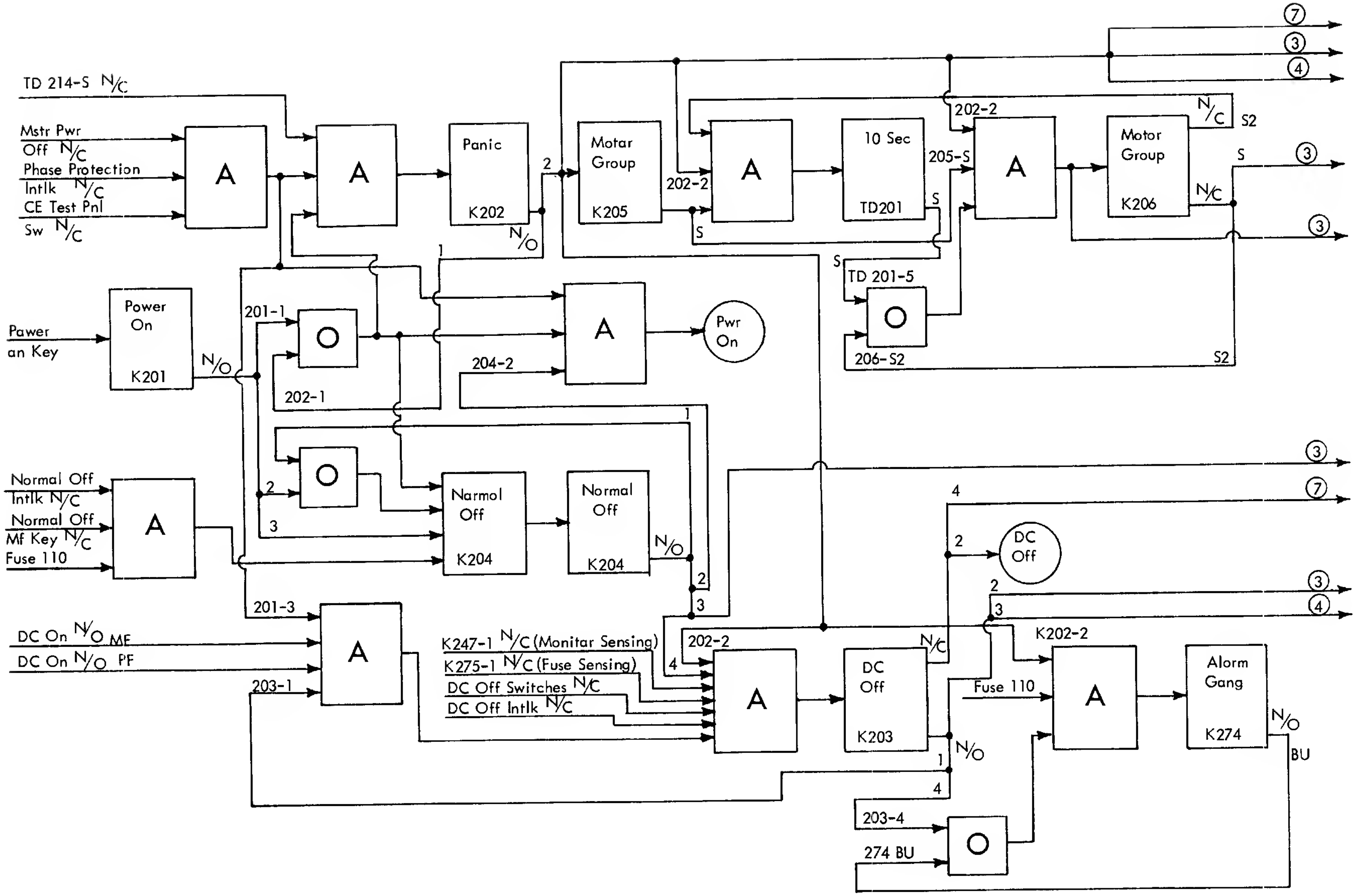


FIGURE 53-3B. AND/OR SEQUENCE OF POWER

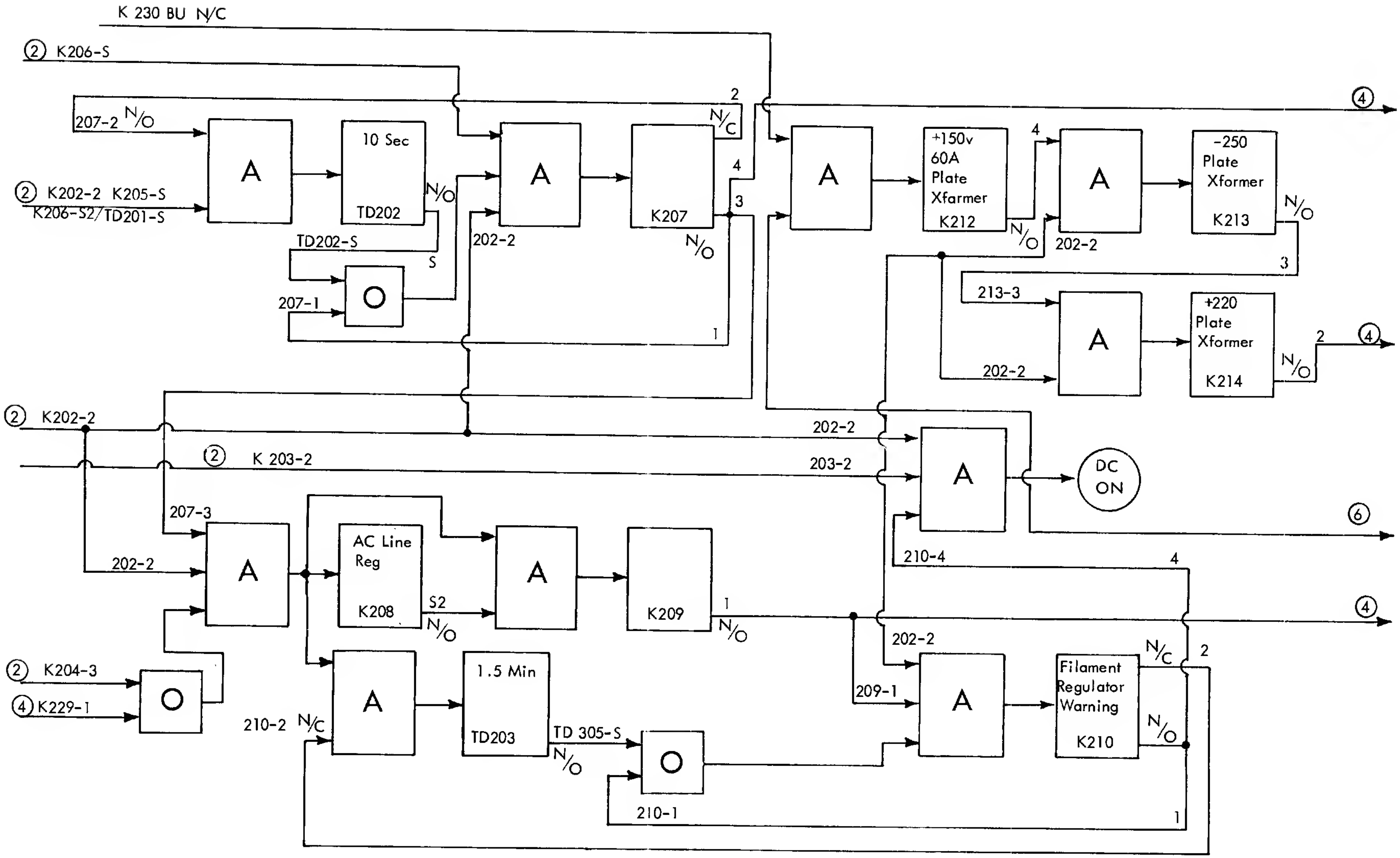


FIGURE 53-3C. AND/OR SEQUENCE OF POWER

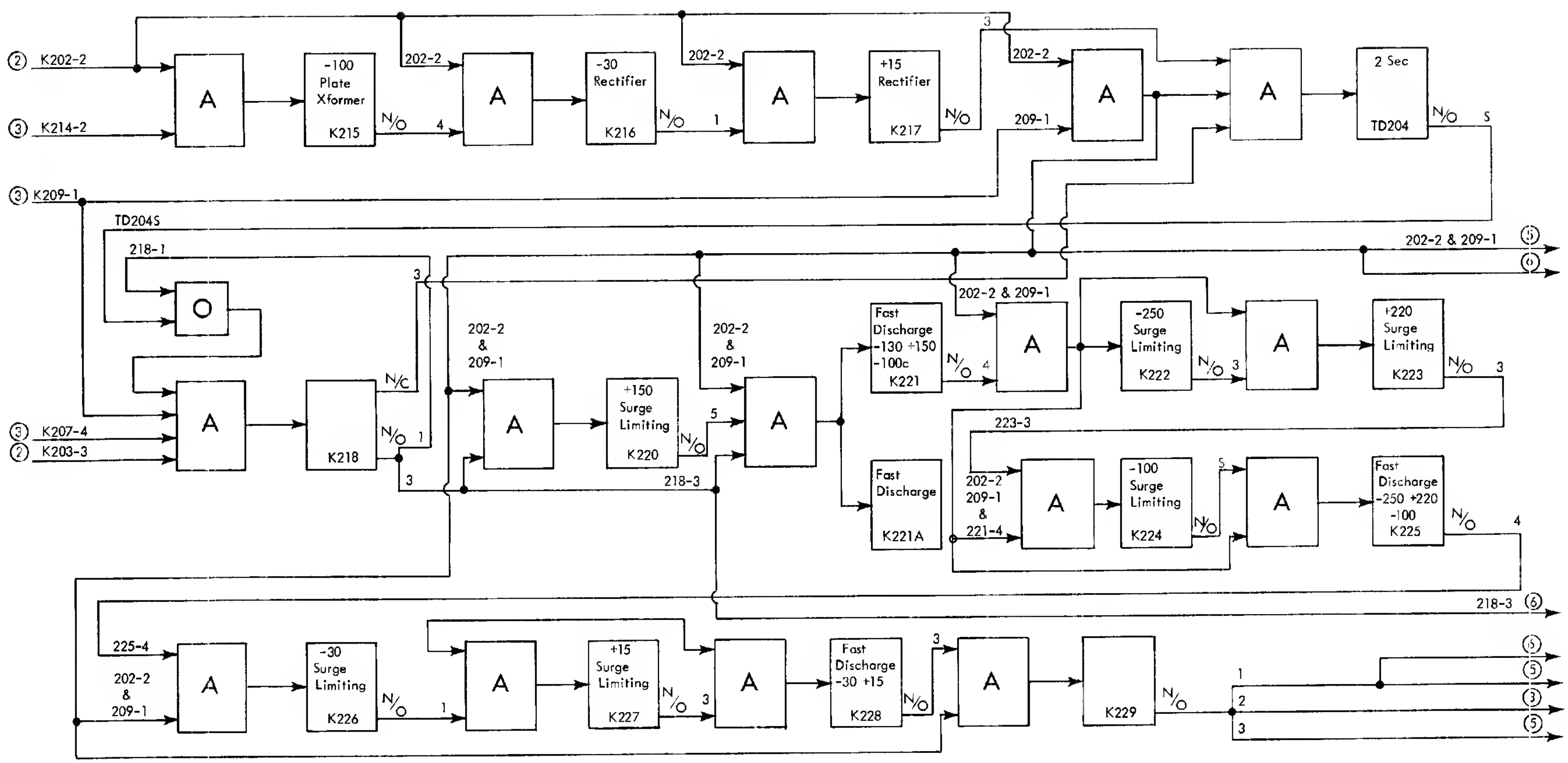


FIGURE 53-3D. AND/OR SEQUENCE OF POWER

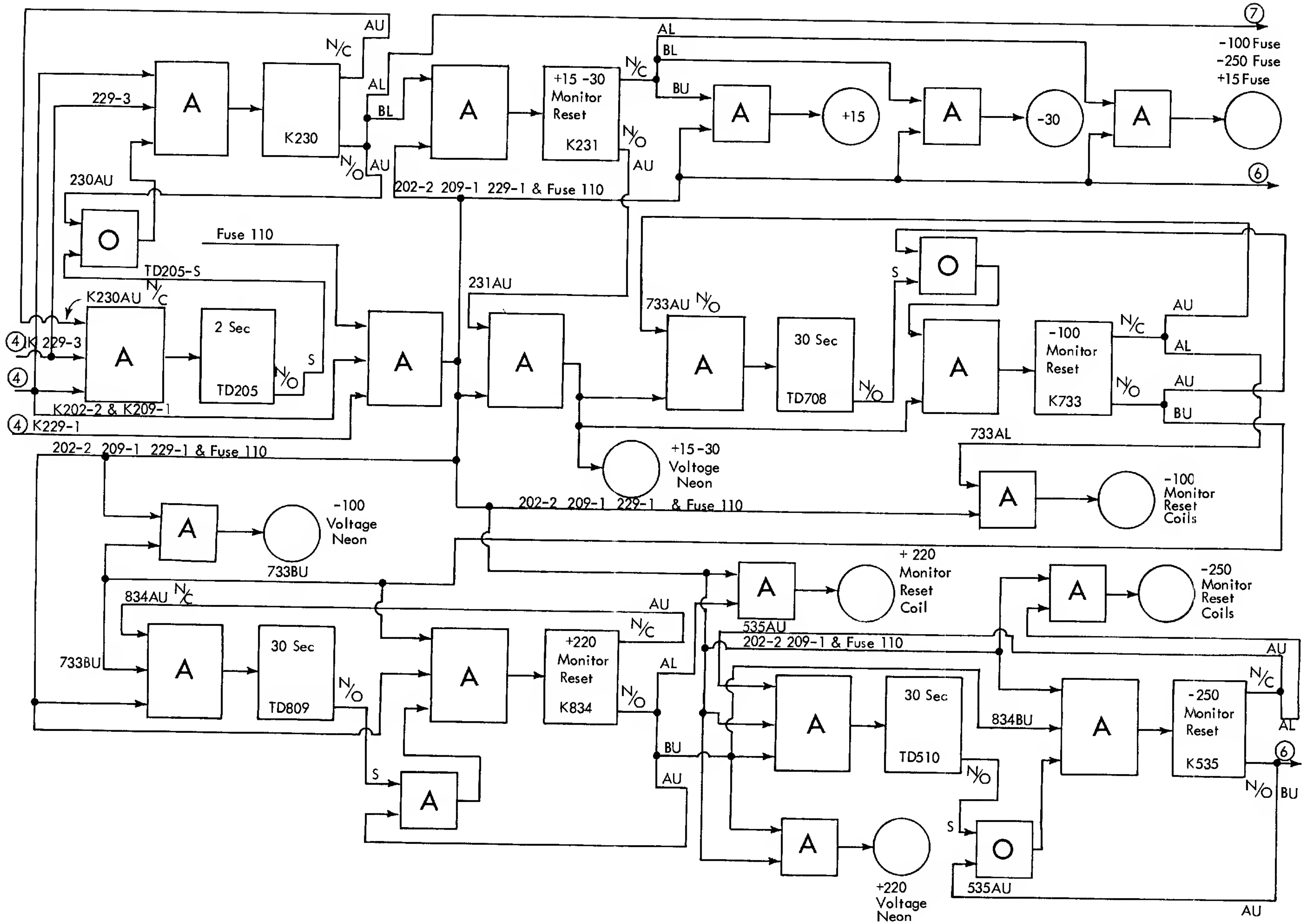


FIGURE 53-3E. AND/OR SEQUENCE OF POWER

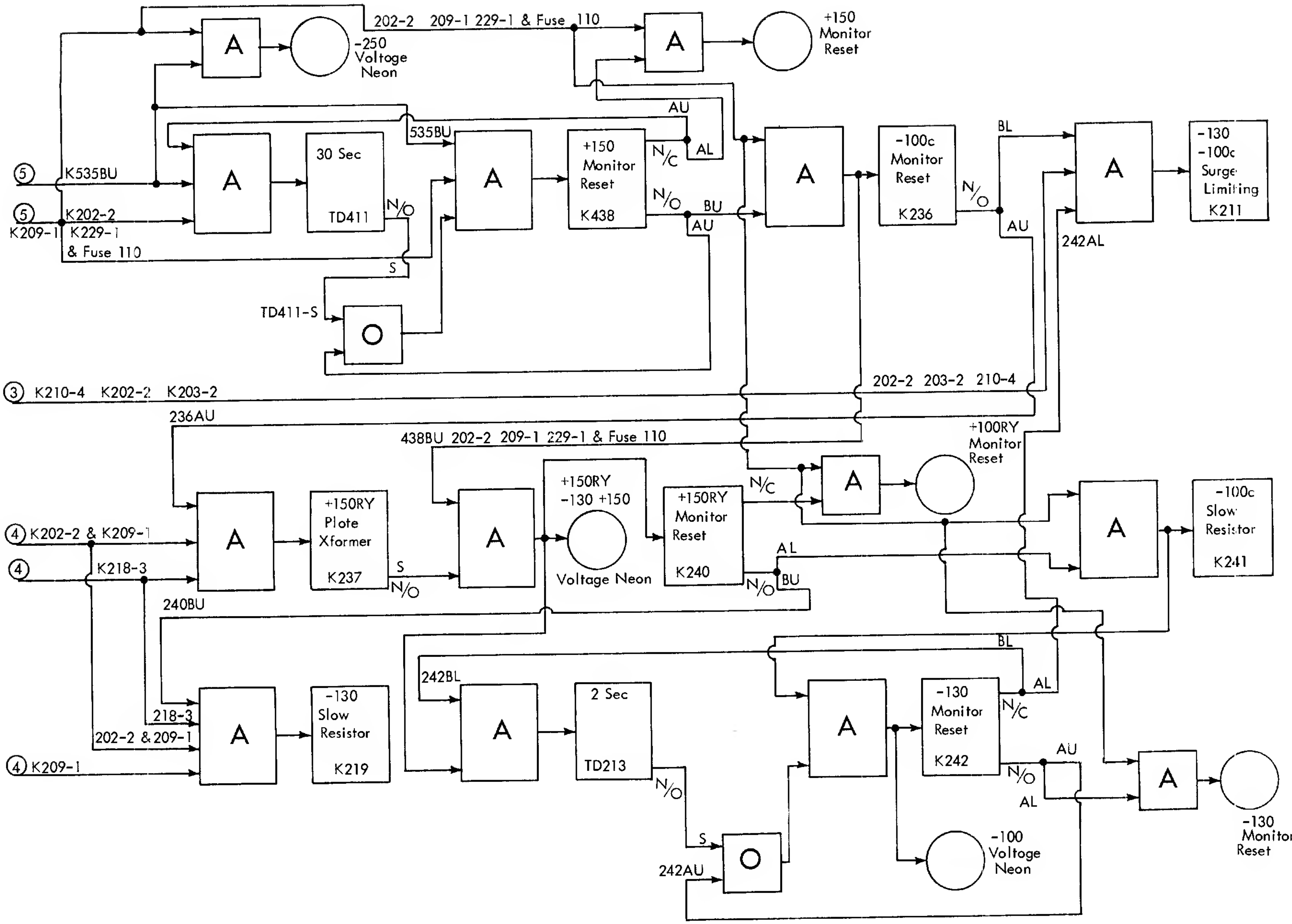


FIGURE 53-3F. AND/OR SEQUENCE OF POWER

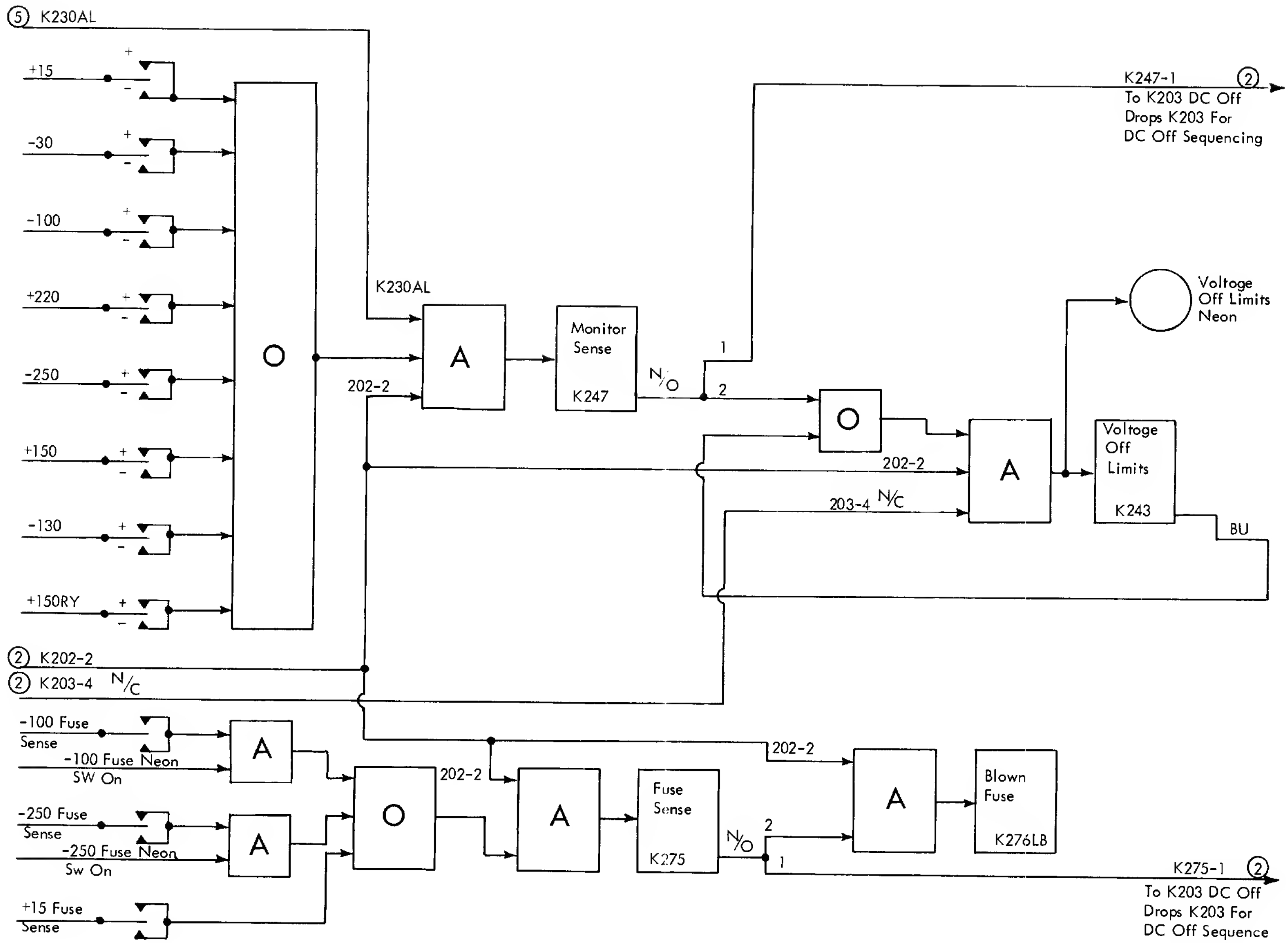


FIGURE 53-3G. AND/OR SEQUENCE OF POWER

PF.54.00 POWER COMPONENT CHARTS

PF.54.01 Power Requirements

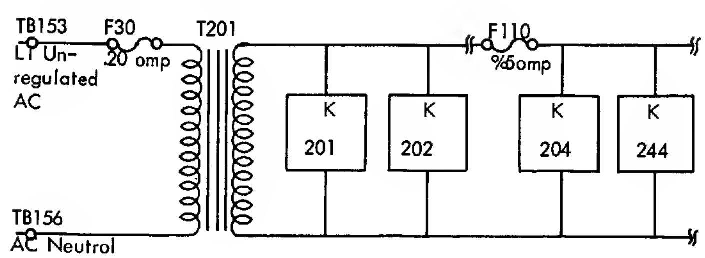
The following readings are from a 704, which consisted of three power frames, main frame, three card machines, tape control with 8 tape drives, one 737 core storage and a drum frame. These are only representative values and will vary with different machines. DC currents were read from the front panel ammeter on the power distribution frame. The AC currents were measured on a Weston clamp on ammeter.

SUPPLY VOLTAGE	CURRENT			CURRENT TRANSFORMER	
	Input Amps	Output Amps		Primary Turns	Secondary Turns
+15	11AC	49DC		2	8
-30	7.9AC	19DC		2	10
-100	18, 19, 20 AC	33DC		4	16
+220	12.5AC	5DC		2	24
-250	8.7AC	6.7DC		2	18
+150 Ry	1.6AC	1.75DC		16	12
+150	27, 27, 25 AC	33DC		3	16
Reg. AC L1	68AC	46AC		1	12
Reg. AC L2	62AC	40AC		1	12
Reg. AC L3	60AC	40AC		1	12
		Motor Group			
		A	B		
Unreg. AC L1	46AC	21AC	25AC	1	10
Unreg. AC L2	43AC	21AC	22AC	1	10
Unreg. AC L3	38AC	16AC	22AC	1	10

Name	Unfused	Fused By F110
Contactor	K201	
Contactor	K202	
Contactor	K203	
Contactor		K204
Contactor	K205	
Contactor	K206	
Contactor	K207	
Contactor	K208	
Contactor	K209	
Contactor	K210	
Contactor	K211	
Contactor	K212	
Contactor	K213	
Contactor	K214	
Contactor	K215	
Contactor	K216	
Contactor	K217	
Contactor	K218	
Contactor	K219	
Contactor	K220	
Contactor	K221A	
Contactor	K221	
Contactor	K222	
Contactor	K223	
Contactor	K224	
Contactor	K225	
Contactor	K226	
Contactor	K227	
Contactor	K228	
Contactor	K229	
Relay	K230	
Relay		K231
Contactor	K232	
Relay		K236
Contactor	K237	
Relay		K240
Contactor		K241
Contactor		K242
Contactor		K243
Contactor	K244	
Contactor	K245	
Contactor	K246	
Contactor		K247
Contactor		K274
Contactor		K275
Contactor		K276
Contactor		K438
Contactor		K535
Contactor		K733
Contactor		K834
Timer Delay	TD201	
Timer Delay	TD202	

Name	Unfused	Fused by F110
Timer Delay	TD203	
Timer Delay	TD204	
Timer Delay	TD205	
Timer Delay		TD213
Timer Delay	TD214	
Timer Delay		TD411
Timer Delay		TD510
Timer Delay		TD708
Timer Delay		TD809
Neons		+15, -30
Neons		-100
Neons		+220
Neons		-250
Neons		-130, +150RY, +150
Neons		-100 C
Neons	PS open fuse	
Neons	Open fuse.frame 1	
Neons	Open fuse frame 2	
Neons	Filament regulation warning	
Neons	Filament regulation auxiliary	
Monitor Reset		+15
Monitor Reset		-30
Monitor Reset		-100 fuse -250 fuse +15 fuse
Monitor Reset		+150 RY
Monitor Reset		+220
Monitor Reset		+150
Monitor Reset		-250
Monitor Reset		-100
Monitor Reset		-130
Buzzer	Filament alarm	
Lights	DC off	
Lights	DC on	
Lights	Normal off	
Lights	Power on	

PF.54.02 Relay Fusing



POWER FRAME TERMINALS				
Terminals	Location	Function	Systems Diagrams	Use
TB 102	Power Frame 1	Rect. Terminal Pnl.	9.01.06	+220v
TB 103	Power Frame 1	Rect. Terminal Pnl.	9.01.06	+15v
TB 104	Power Frame 1	Rect. Terminal Pnl.	9.01.06	+150v
TB 105	Power Frame 1	Rect. Terminal Pnl.	9.01.06	AC line regulator
TB 106	Power Frame 1		9.01.08	L1, L2, L3 regulated AC
TB 107	Power Frame 1		9.01.08	L1, L2, L3 blower motor 1
TB 108	Power Frame 1		9.01.08	L1, L2, L3 blower motor 2
TB 109	Power Frame 1		9.01.08	L1, L2, L3 blower motor 3
TB 110	Power Frame 1		9.01.08	L1, L2, L3 unregulated AC & L2 AC outlet
TB 111	Power Frame 1		9.01.08	Blank
TB 112	Power Frame 1		9.01.08	Blank
TB 113	Power Frame 1		9.01.08	Blank
TB 114	Power Frame 1		9.01.08	Blank
TB 115	Power Frame 1		9.01.08	Master power off, normal off, thermal switch, fuse alarm relay
TB 116	Power Frame 1		9.01.08	L1, L2, L3 AC regulator intlk DC off (K2065B)
TB 117	Power Frame 1		9.01.08	+220v J821 intlk, RS intlk J875
TB 118	Power Frame 1		9.01.08	+150v J421 intlk, RS intlk J475
TB 119	Power Frame 1		9.01.08	+15v J921 intlk
TB 120	Power Frame 1		9.01.08	L1, L2, L3 AC regulator
TB 121	Power Frame 2	Rect. Terminal Pnl.	9.01.07	+150v
TB 122	Power Frame 2	Rect. Terminal Pnl.	9.01.07	-250v
TB 123	Power Frame 2	Rect. Terminal Pnl.	9.01.07	-30v
TB 124	Power Frame 2	Rect. Terminal Pnl.	9.01.07	-130v
TB 125	Power Frame 2	Rect. Terminal Pnl.	9.01.07	-100v
TB 126	Power Frame 2		9.01.09	L1, L2, L3 regulated AC
TB 127	Power Frame 2		9.01.09	L1, L2, L3 blower motor 4
TB 128	Power Frame 2		9.01.09	L1, L2, L3 blower motor 5
TB 129	Power Frame 2		9.01.09	L1, L2, L3 blower motor 6
TB 130	Power Frame 2		9.01.09	L1, L2, L3 unregulated AC
TB 131	Power Frame 2		9.01.09	Blank
TB 132	Power Frame 2		9.01.09	Blank
TB 133	Power Frame 2		9.01.09	Blank
TB 134	Power Frame 2		9.01.09	Blank
TB 135	Power Frame 2		9.01.09	Master power off, normal off, thermal switch, fuse alarm relay
TB 136	Power Frame 2		9.01.09	DC off, fuse alarm relay (-100v) J721
TB 137	Power Frame 2		9.01.09	-100v J721, RS intlk J775, -250v J521
TB 138	Power Frame 2		9.01.09	-250v VC intlk J521, RS intlk J575, Fuse 833 and 825
TB 139	Power Frame 2		9.01.09	-130v VC intlk J221, -30v VC intlk J1021
TB 140	Power Frame 2		9.01.09	Blank
TB 141	PDF		9.01.04	AC line regulator
TB 142	PDF		9.01.04	PF1 sequencing ckts
TB 143	PDF		9.01.04	PF1 sequencing ckts
TB 144	PDF		9.01.04	PF2 sequencing ckts
TB 145	PDF		9.01.04	PF2 sequencing ckts
TB 146	PDF		9.01.04	Surge limiters PF1 and 2
TB 147	PDF		9.01.04	DC outlets
TB 148	PDF		9.01.04	PF1 misc. AC ckts (1-16)
TB 149	PDF		9.01.04	PF2 misc. AC ckts (6-16)
TB 150	PDF		9.01.04	PF2 misc. AC ckts (1,2), PF1 AC feeds (13-16)
TB 151	PDF		9.01.04	PF1 AC feeds (1,2), PF2 AC feeds (6-11)
TB 152	PDF		9.01.04	DC zero volts
TB 153	PDF		9.01.04	L1
TB 154	PDF		9.01.04	L2
TB 155	PDF		9.01.04	L3
TB 156	PDF		9.01.04	AC neutral
TB 157	Power Frame 1		9.01.08	Connection
TB 158	Power Frame 2		9.01.09	Connection
TB 159	PDF		9.01.05	AC neutral

PF.61.00 COMPONENT LOGIC

PF.61.01 Thermistor

In the filament-voltage regulating circuit, a thermistor unit is used for obtaining an alternating voltage of constant amplitude, having the same wave shape and phase as the controlled voltage for use as a reference standard. The controlled voltage is then compared with this standard voltage and the difference voltage is amplified and rectified in a two-stage push-pull amplifier. The second amplifier controls the bias on the current regulator tube and determines the amount of current that is furnished to the DC winding of the saturable reactor. This counteracts any attempt to change the regulated voltage. This regulated circuit is shown in block form in Figure 61-1. Before preceeding with a detailed discussion of the regulating circuit the thermistor is described.

The thermistor unit shown in Figure 61-2 contains a pair of thermistor beads and a positive temperature-coefficient resistor connected in series and closely coupled together thermally. This assembly is then surrounded by heat-insulating material and sealed in a metal container with the two leads brought out to the top of the can by means of sealed insulating bushings. Properties of the unit should not be affected by external air pressure or humidity.

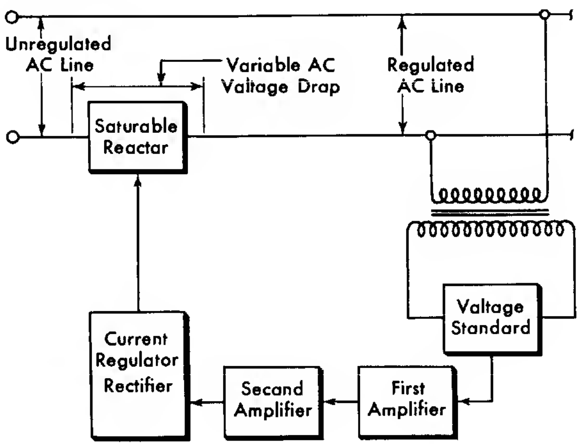


FIGURE 61-1. BLOCK DIAGRAM, AC REGULATED CIRCUIT

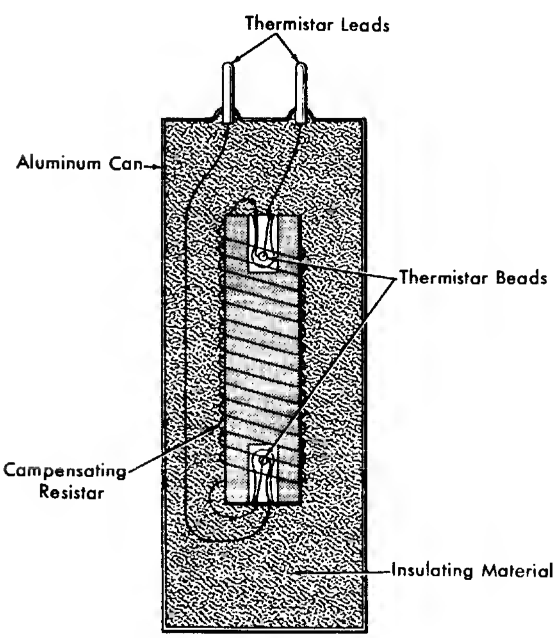


FIGURE 61-2. THERMISTOR

The thermistor beads are of a semi-conducting material which increases in conductivity at a very rapid rate with increasing temperature and, consequently, with increasing current through the material. A typical volt-amphere characteristic for a thermistor bead is shown in Figure 61-3.

It can be seen that in the operating range the bead has a decided negative resistance characteristic, that is, the voltage drop across the bead decreases with an increasing current. The thermal time constant of the bead is sufficiently long (about one second) so that no great change occurs in its resistance in one cycle of a 60-cycle wave. The wave shape of the voltage appearing across the bead then corresponds to the wave shape of the current through the bead, but the steady-stage voltage decreases with an increase in the steady-state current through the operating range, as shown in Figure 61-3.

The compensating resistor has a positive temperature coefficient of resistance and is selected for resistance and coefficient of resistance so that the steady-state voltage across the combination of the thermistor bead and the resistor remains constant within the operating range. If the surrounding temperature varies a great deal, the volt-amphere characteristic is altered, but this should present no problem under normal operating conditions.

PF.61.02 Saturable Reactor

A variable AC-voltage drop across a saturable reactor provides a means for regulating the voltage of an AC supply line. This principle can also be used as a means of regulating the output of a DC rectifier supply by controlling its AC input. Before discussing the regulating circuits, the principle of operation of a saturable reactor is described.

The magnetic flux within the iron core of a transformer does not increase in direct proportion to the magnetizing current. Once the iron core is saturated, further increase in magnetizing current produces no increase in magnetic flux. In a normal transformer, the saturation point of the core is rarely reached, but the saturating effect is used to advantage in the saturable reactor.

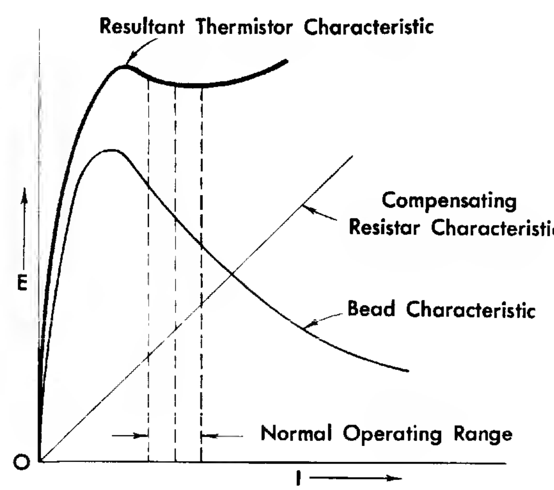


FIGURE 61-3. VOLT-AMPERE CHARACTERISTICS OF THERMISTOR

A saturable reactor usually consists of a three-legged reactor in which the two outer legs are supplied with AC while the center leg is supplied with DC, as indicated in Figure 61-4A. Windings A and B on the two outer legs are in parallel but would be wound in opposite directions, so that the magnetic flux from windings A and B cancel in the center leg. This is indicated by the dotted field in Figure 61-4A. The saturable reactor is inserted in the AC line, and since the normal reactance of windings A and B is very high, there is a considerable drop across the reactor. If a third coil, C, is wound on the center leg, and DC is supplied to its winding, it is possible to vary the reactance of the windings A and B in the following way.

The DC supplied to the center winding sets up the magnetic field in the core with an intensity dependant upon the amount of DC current furnished to coil C. Suppose sufficient DC is supplied to almost saturate the core, as represented by (Figure 61.4B). Since flux saturation occurs at current value b, no great increase in flux is possible. When AC is applied to the A and B windings, very little increase in flux results from the AC. Since it is a changing magnetic field that produces the back EMF which creates the reactance of a coil, the reactance of windings A and B are very low. If the reactance of the A and B windings is low, then the AC voltage drop across the reactor is low. By varying the amount of current in the DC winding, the reactance of windings A and B can be varied from a maximum to almost zero. In the AC line regulator the amount of DC current furnished to the reactor is controlled by a regulating circuit. This principle is illustrated in Figure 61-1. Because the saturable reactor operates at or near saturation, harmonics are introduced in the output, thereby distorting the AC wave shape. This means that a conventional AC meter using a rectifier in series with a DC movement does not show correct voltage readings. An iron vane meter correctly indicates an AC voltage even though it is distorted by the presence of harmonics. The AC meter mounted in the power distribution frame is of this type and should always be used when measuring the regulated AC line.

PF.61.03 AC Line Voltage Regulator

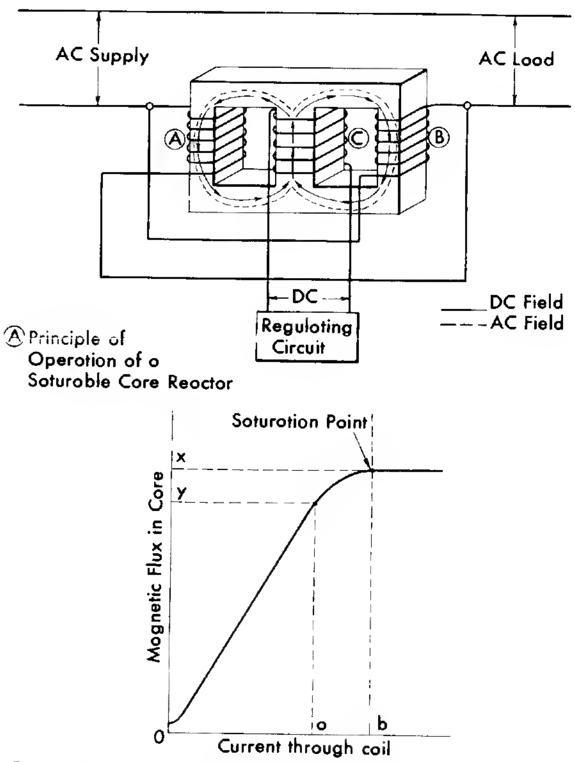
The AC line voltage regulators shown in Systems diagrams, 9.11.01 and 9.11.02 have been simplified in Figure 61-8. These regulators maintain each regulated AC line at 120 volts ± 1 percent from AC neutral. The secondary coils of transformer T2 have been separated to facilitate analysis. Reading from left to right, all coils have the same polarity during any particular half-cycle. The voltages shown are for normal operation, the alternating voltages being RMS values. The regulated inputs to transformer T-1 and T-2 are fed back from the output of the regulator.

Static Operation

Note that the operation of the circuit is first in a static stage and that input and output voltages are at their normally rated values. Consider the voltages at the grids of the first amplifier, V-1. The common cathodes of the first amplifier connect to one side of the thermistor, while the two grids connect to secondary taps 9 and 10 of transformer T-2. The grid-to-cathode voltages are, therefore, of net voltage between taps 9 and 10 and the end of the thermistor labeled A. During the half-cycle with the polarities as indicated in the figure, the grid voltage of V-1A will be 60 volts, -62 volts, or -2 volts. Likewise, the grid voltage of V-1B is volts, -58 volts, or 2 volts.

Since the plate of V-1B is negative during this half-cycle, V-1B does not conduct. However, on the next half-cycle the grid and plate voltages are interchanged between V-1A and V-1B. On the half-cycle that V-1A conducts, current flows through resistor R2 and produces a voltage drop of about 50 volts. On the next half-cycle, when V-1B conducts, current flows through R3 and produces an equal voltage drop.

The voltages developed across resistors R2 and R3 are used in conjunction with transformer output voltages to control the grids of the second amplifier. The common cathodes of the second amplifier are connected to one end of resistor R2 (point B), while the grids of the second amplifier are connected to



(A) Principle of Operation of a Saturable Core Reactor

(B) Current through coil VS. Magnetic Flux in Core

FIGURE 61-4. SATURABLE CORE REACTOR

transformer taps 12 and 13. Thus, the cathode-to-grid voltage at V-2A of the second amplifier includes the voltage across R2 and the voltage between transformer taps 11 and 13. There is no drop across R3 during this half-cycle. The cathode-to-grid voltage of V-2B of the second amplifier during the half-cycle, in which it can conduct, includes the voltage across R3 and the voltage between taps 11 and 12. In each circuit, the two voltages oppose, resulting in a 3v signal at the grids of V-2.

During the half-cycle, when the negative signal is applied to the grid of the V-2A, the plate is positive. Therefore, V-2A conducts to produce a 110v drop across resistor R4. On the other half-cycle, the V-2B conducts to produce a 110v drop of the same polarity across R4. Thus, positive, unidirectional, pulsating voltages are developed between point C and transformer taps 17 since rectifiers CR1 and CR2 connect point C to tap 16 and 18 during alternate half-cycles. This pulsating voltage has the opposite polarity of that across R4. Thus, the grids of V-3 are placed at a minus 40 potential with respect to the cathode. The conduction level of V-3, the current regulator, is thus set to control the output of rectifier V-4. Since the DC winding of the saturable reactor is in series with the rectifier V-4, the output current of the rectifier adjusts the reactance of the saturable reactor to produce a regulated line voltage of 120 volts AC.

Regulating Action of AC Line Voltage Regulator

So far, operation of the circuit with rated input and output voltages has been described. Regulating action for an increase in line voltage is now analyzed during both positive and negative half-cycles. Voltages given in this analysis are strictly assumed values, taken in one instant during each of the half-cycles. An application factor of five is assumed at both stages of amplification. Actually, the amplification factor is about 16.

Positive Half-Cycle (Low Numbered Taps Positive). Since the anode of V-1B is negative during this half-cycle, V-1B does not conduct. The grid-to-cathode circuit of V-1A includes the voltage across the thermistor and the voltage between the potentiometer tap and transformer tap 10. With an increase in the line voltage, the first voltage remains at 60 volts but the second voltage is assumed to increase from 62 to 63 volts. The grid-to-cathode voltage is then 60 volts minus 63 volts, or minus three volts. Since this grid voltage is one volt lower than normal, the plate current through V-1A decreases, and reduces the voltage across R2 to 45 volts.

With respect to the cathode of V2 (or point B), the grid voltage of V-2A is the voltage across R2 (45 volts) minus the voltage between taps 11 and 13 (53 volts), or minus eight volts. For this illustration, it is assumed that the transformer secondary voltages do not increase with the regulated line voltage. Actually, these voltages do change but the changes are small in comparison with those across R2 and R3. Also, the changes are of such polarity that they assist the regulating action of the circuit. The plate current of V-2A flows through R4, but is reduced and produces a voltage drop of only 85 volts. The grid voltage of V-3A, with respect to the cathode, is the voltage across R4 (85 volts) minus the voltage between taps 16 and 17 (150 volts), or minus 65 volts. Since this grid voltage is lower than normal, the direct current from rectifier V-4 to the DC winding of the saturable reactor is reduced.

The decrease in the saturating current increases the impedance of the saturable reactor and the resulting voltage drop across its terminals. This increase in voltage drop across the saturable reactor reduces the voltage which the buck-boost transformer contributes to the line voltage and thereby, decreases the regulated voltage. This minimizes the attempted increase in line voltage.

Negative Half-Cycle (Low Numbered Taps Negative). Since the anode of V-1A is negative during this half-cycle, V-1A does not conduct. The grid-to-cathode circuit of V-1B includes the voltage across the thermistor and the voltage between the potentiometer point and tap 9. With an increase in line voltage, the first voltage remains at an instantaneous value of 60 volts, but the second voltage is assumed to increase to 59 volts. The grid-to-cathode voltage is then 59 volts minus 60 volts, minus one volt. Since this grid voltage is one volt higher than normal, the plate current through V-1B increases, and thus increases the voltage across R3 to 55 volts.

With respect to the cathode of V-2 (or point B), the grid voltage of V-2B is the voltage between taps 11 and 12 (47 volts) minus the voltage across R3 (55 volts), or minus eight volts. The plate current of V-2B flows through R4 and again produces voltage drop of only 85 volts. The grid voltage of V-3A, with respect to the cathode, is the voltage across R4 (85 volts) minus the voltage between taps 17 and 18 (150 volts), or minus 65 volts. Sinee this grid voltage is lower than normal, the direct current from rectifier V4 to the DC winding of the saturable reactors is reduced. The AC voltages across the reactor and the buck-boost transformer are adjusted to compensate for the attempted increase in line voltage.

Operation of the circuit during an increase in line voltage has been described. An analysis for a decreased line voltage shows that the circuit operates in a similar manner to maintain a regulated output voltage.

PF. 61. 04 Buck-Boost Transformer

The buck-boost transformer is an auto transformer with a turns ratio of about 4 to 1. These windings are in series and the voltage across the large winding is about four times as great as voltage across the small winding. These voltages are in phase as in any auto transformer.

The AC windings of the saturable reactor are connected in series with the large winding of the buck-boost transformer as shown in Figure 61-5. Regulation is actually accomplished by a phase-shift principle. The current through the outside legs of the saturable reactor and large winding of the buck-boost transformer is about one-fourth the current through the small winding. The current through the small winding is the same as the load current.

If the input voltage could drop until there is a maximum DC current flow through the central leg of the saturable reactor, there would be no reactance to the input voltage and the saturable reactor is effectively a resistor. The buck-boost transformer now boosts the input voltage as an auto transformer. The maximum output voltage is about 5/4 the input voltage. This is the extreme condition of the action by which the input voltage drops but a regulated AC output is maintained.

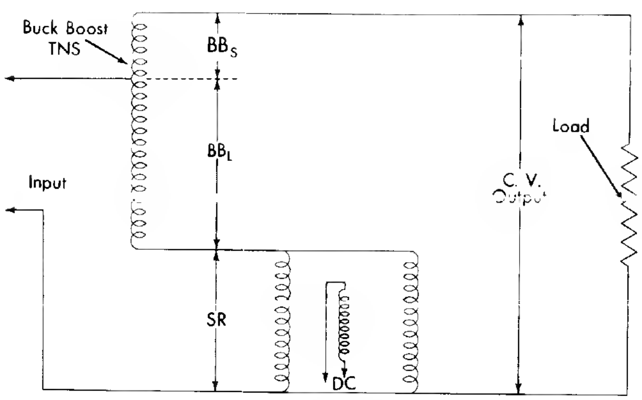


FIGURE 61-5. BUCK-BOOST TRANSFORMER AND SATURABLE REACTOR

When the input voltage rises, DC current flow through the center leg of the saturable reactor is minimum. The constant AC voltage is maintained because the reactor has a large reactance to the line voltage. The voltage drop across the saturable reactor increases because of the increased reactance of the saturable reactor to the input. This causes an increased phase shift between the saturable reactor and the input.

The voltage relationships of the two windings of the buck-boost transformer and the saturable reactor are shown in Figure 61-7. These voltages are taken with the auto transformer taps connected for 210 volts and read by a Simpson Meter, Model 260.

A low-line voltage of 180 volts results in high DC current flow through the control winding of the saturable reactor and an AC voltage drop of 162 volts across the outside legs. The large winding of the buck-boost has a 175v drop and the small winding has a 50v drop.

A 210v line input causes a decrease in DC current through the control winding of the saturable reactor and an increase in the AC voltage drop across the outside legs of the reactor to 400 volts. The voltage in the large and small windings of the buck-boost is increased to 310 volts and 78 volts respectively. A 250v line input causes still more decrease in DC currents through the control winding and a greater AC voltage drop (555 volts) across the outside legs of the reactor. Voltage drop across the buck-boost transformer windings also increases to 412 volts across the large winding and 115 volts across the small winding.

The small winding of the buck-boost transformer either boosts the line voltage to the constant AC output or bucks the line voltage, if it is greater than the constant output voltage. With a line change from 180 to 250 volts, the voltage drop across the small winding changes from 50 to 115 volts while the drop across the saturable reactor changes from 162 to 555 volts. This means that a large change in voltage drop across the saturable reactor results in a comparitively small change in drop across the small winding to the buck-boost transformer, and regulation is maintained.

The 180v and 250v inputs are beyond the 10 percent limits but are used to illustrate the regulation principle.

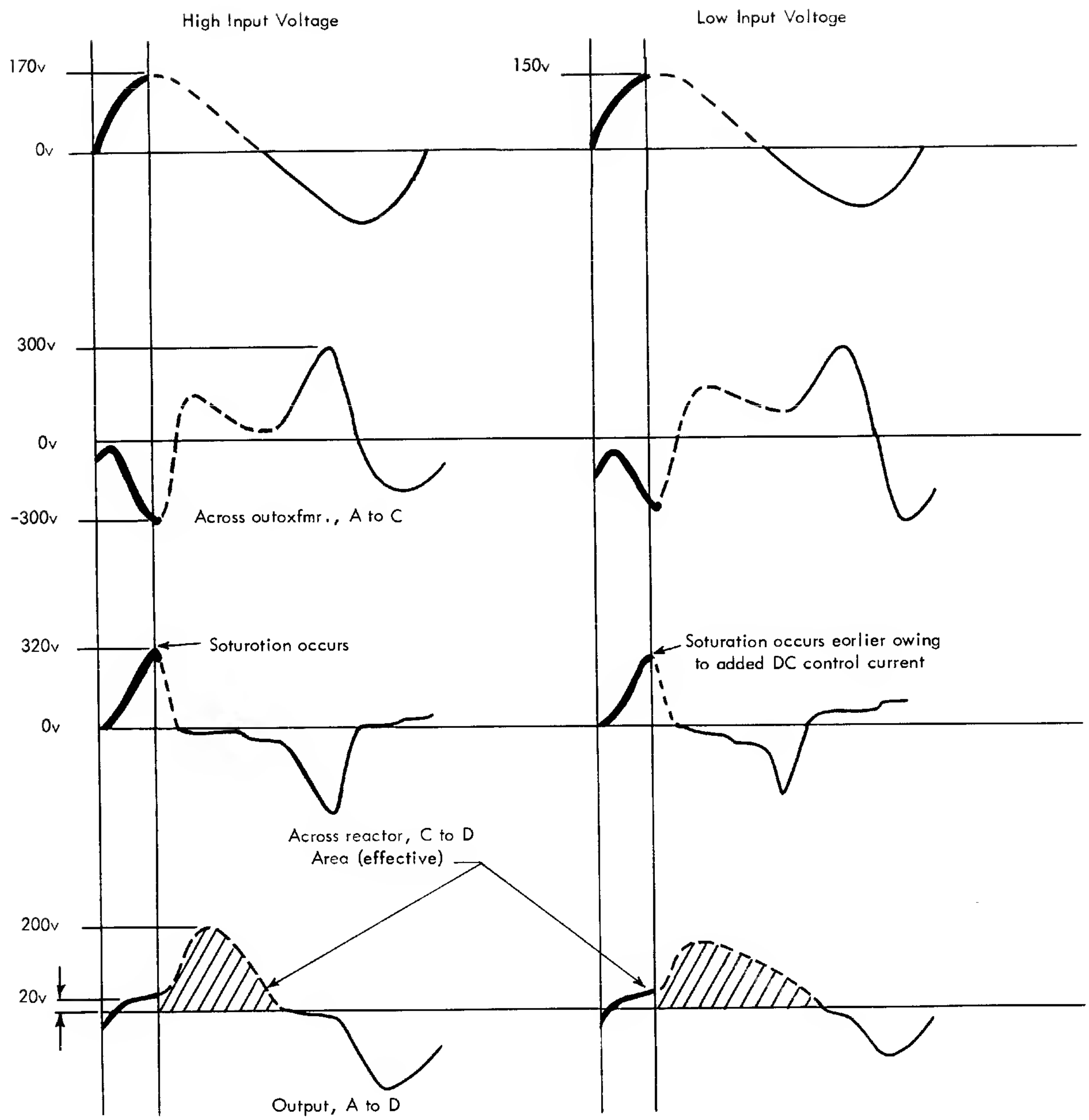


FIGURE 61-6. BUCK-BOOST TRANSFORMER AND SATURABLE REACTOR WAVE FORMS.

AC Input	SR Cantral Winding Current
180V	175 Mo
210V	130 Mo
250V	87 Mo

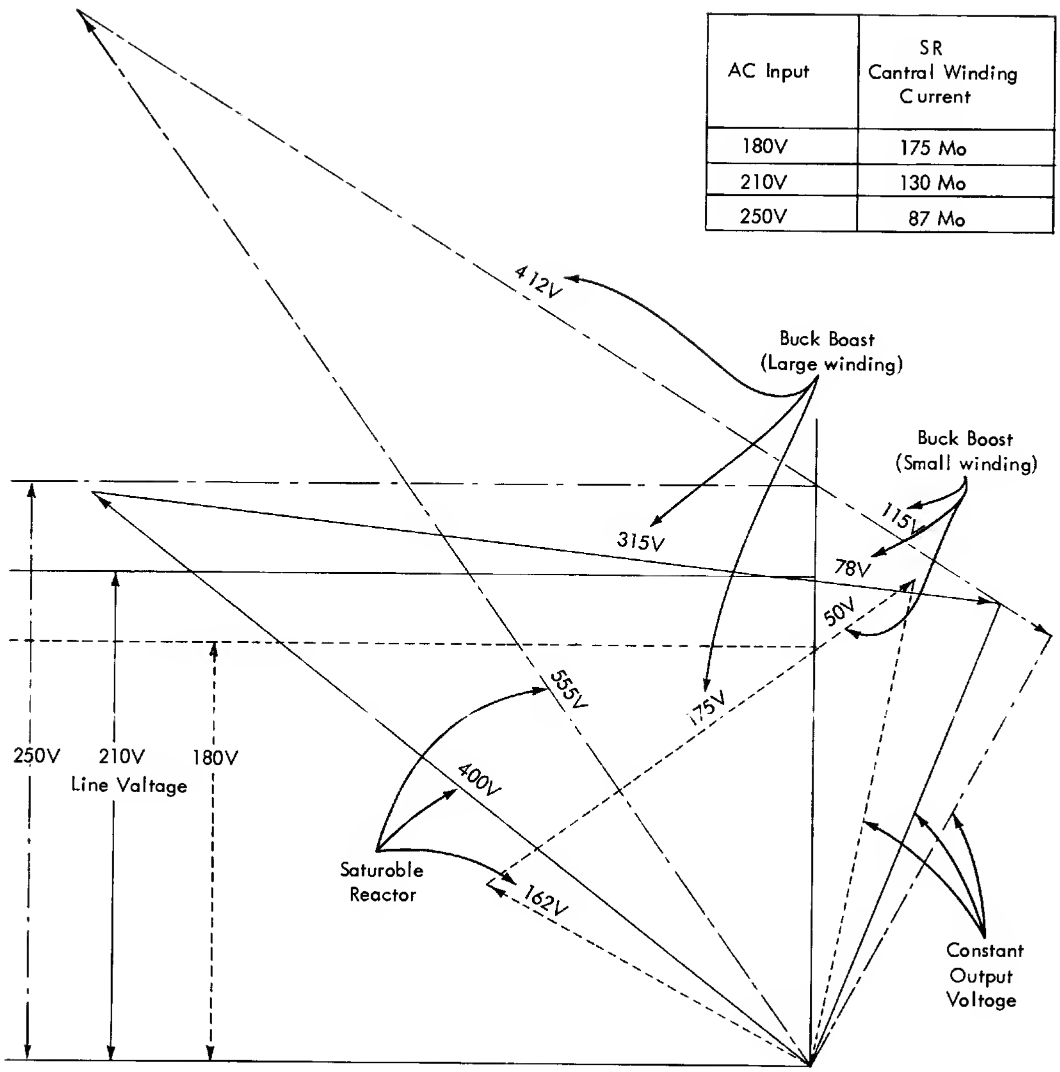


FIGURE 61-7. BUCK-BOOST TRANSFORMER AND SATURABLE REACTOR VOLTAGE MEASUREMENTS

PF.61.05 AC Line Regulator Circuit (Systems Diagrams, 9.11.01 and 9.11.02)

Two transformers are used in the regulating circuit, TB05 and TB06. TB05 supplies the rectifier, VB06, and all the filaments of the regulating circuit tubes. TB06 is the control transformer supplying the thermistor circuit and the two amplifiers. The thermistor is connected across taps 3 and 4 of the transformer TB06 and the voltage across it remains constant at about 60 volts.

The first amplifier consists of the upper twin triode tube, VB08, along with its associated circuits. Resistors, RB27 and RB21, serve as load resistors on alternating half-cycles of the AC wave form. The two triode sections provide one stage of push-pull amplification with each triode operating on alterante half-cycles from the applied AC voltage.

The first amplifier controls the second amplifier, which consists of the lower twin triode, VB07, along with its associated circuits. Resistor RB22 serves as the common cathode resistor for both sections of the tube.

The four varistors (selenium rectifier disks) associated with the second amplifier circuit serve as a rectifier to produce a DC control voltage for the current regulator tubes.

The second amplifier output voltage controls the amount of current that the current regulator tuhes pass to the saturable-reactor DC winding. The current regulator consists of two tetrodes, VB04 and VB07, operating in parallel to increase the current carrying capacity. A direct current to the saturable reactor is produced by the full-wave rectifier, VB06. The resistors in the individual cathode circuits of the tubes VB04 and VB07 serve to equalize the load between the two parallel tubes. If one tube attempts to draw more than its share of current, the increased drop across its cathode resistor drives its cathode more positive, thereby reducing the current flow.

The filaments of tubes VB08 and VB09 are connected in series so that failure of either filament (through burnout or removal of a tube) results in reduced output from the regulator and thereby protects the apparatus. The values of the grid resistors are sufficiently high so that any grid current which flows during the half-cycle when the grids are positive with respect to their cathodes, is so small that it has little effect on the voltages and other parts of the circuit.

PF.61.06 High-Low Voltage Relay Control Operation (Systems Diagram, 9.11.02, sheet 1)

Each of the three AC line regulators has an associated high-low voltage relay control circuit. The control circuit operates to close relay contacts to energize an alarm buzzer and neon or give a normal off when the output voltage of the regulator varies excessively. Within five percent of rated value, the relay remains energized, holding the contact open.

The control circuit is shown in Figure 61-9 with the secondary coils of transformer T-1 separated to facilitate analysis. Reading from left to right, all coils have the same polarity during any particular half-cycle.

The operation of the high-low voltage relay control is similar to that of the AC line voltage regulator. The standard voltage across the thermistor is compared with the voltage across potentiometer R1 and rheostat R2. The latter voltage is proportional to the output voltage of the regulator. The difference voltage is placed in the grid-to-cathode circuit of amplifier tube V-1. The output voltage of this amplifier appears across resistors R3 and R4 alternately, and, when combined with an alternating voltage obtained between taps 4 and 5 of transformer T-1, has the form of a full-wave rectifier voltage. The amplitude and polarity of this rectified voltage depends upon the direction of departure of the input voltage from the set value. For example, with an increase in transformer input voltage, the voltage across R3 be-

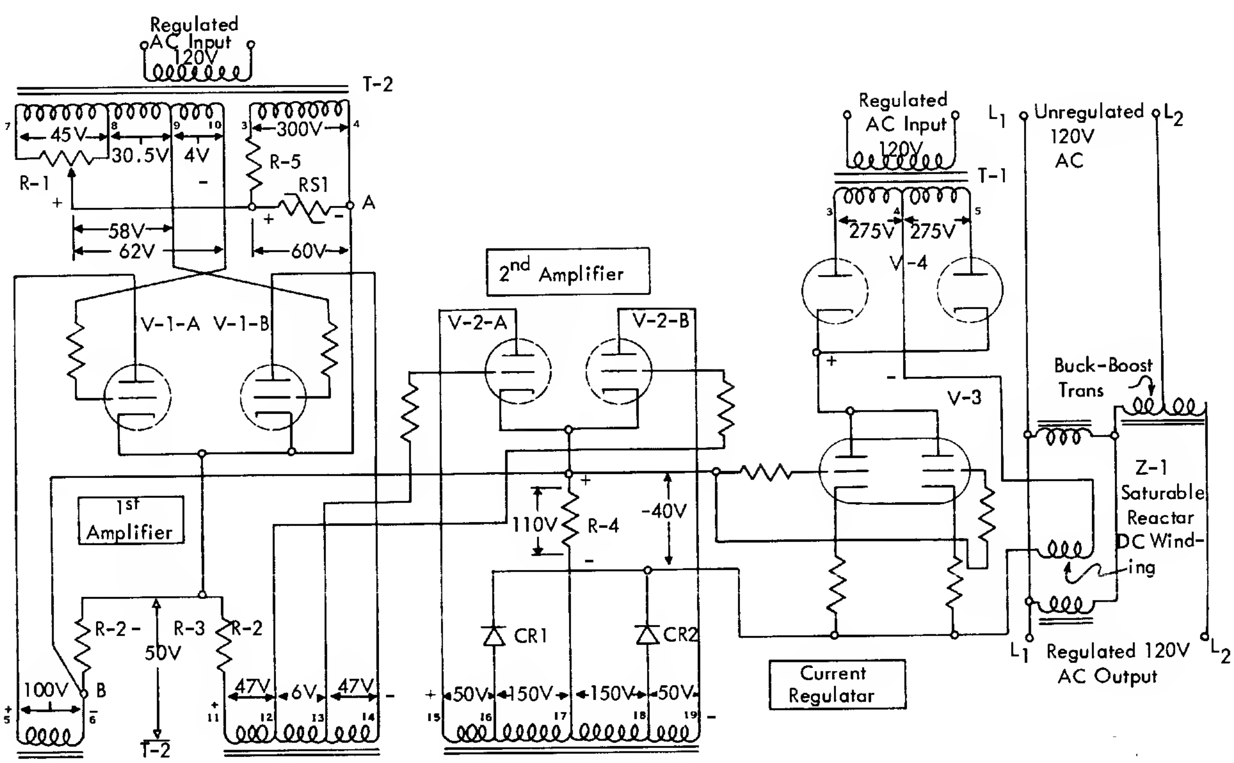


FIGURE 61-8. AC LINE VOLTAGE REGULATOR

comes larger than the voltage between transformer taps 4 and 5, while the voltage across R4 becomes smaller than the voltage across transformer taps 4 and 5. On the half-cycle where there is a voltage across R3, this voltage and the voltage between taps 4 and 5 add to make point A positive. By similar analysis, it can be shown that point A is negative during positive and negative half-cycles of a decreased line voltage.

Thus, a full-wave rectified voltage is applied to rectifier V2 and V3. The output of V2 and V3 appears as a unidirectional voltage across R5. That is, with either an increased or decreased line voltage, the voltage across R5 has the same polarity.

The voltage across R5, along with the AC voltages between taps 7-8 and 8-9, is included in the grid-cathode circuit of V4. This direct voltage sets the output level of V4. With rated input voltage to transformer T1, the current through the coil of relay K1 is sufficient to hold the contacts open. Should the input voltage depart from the normal value, the voltage across R5 increases, making the grids of V-4 more negative. The output of V-4 decreases; its voltage across R5 increases, until the relay contacts open.

High-Low Voltage Relay Control Circuit

Transformer TB04 (Systems diagram, 9 11.02, sheet 1), which supplies the control, takes its input from line to neutral on the output side of the AC line voltage regulator. A thermistor is connected across taps 18 and 19 of transformer TB04 to furnish the standard voltage; the twin triode tube VB05 and its associated circuits comprise an amplifier. Resistors RB27 and RB20 serve as load resistors on alternate half-cycles in the AC wave form. The twin triode sections provide one stage of push-pull amplification with each triode operating on alternate half-cycles.

The output voltage of the amplifier appears across resistors RB27 and RB20 alternately, and when combined with the AC voltage between taps 4 and 5 from the transformer, has the form of a full-wave rectified voltage. Its amplitude and polarity are dependent on the departure of the input voltage of the transformer from the reference level. A full-wave bridge rectifier changes the output to a unidirectional voltage which appears across resistor RB19 and PU B02. Since resistor RB19 is in the grid cathode circuit of tube VB03, the voltage across the resistor controls the output of the tube. The rectifier amplifier tube supplies current as a full-wave grid-controlled rectifier to the operating coil of relay KB01.

Capacitor CB01 is placed across the relay coil to delay the operation, this assuring that the relay is not opened by momentary line surges. The introduction of this capacity loaded on the amplifier tube was found to give an oscillation in the output stage. The addition of the capacitance CB02 in plug-in unit, PU B02 eliminates this tendency to oscillate.

Adjustment of potentiometer RB01 and rheostat RB02 can be accomplished in the following manner. With rheostat RB06 at the center position and the regulated output voltage set to the desired value, adjust potentiometer RB01 until a near-maximum voltage is obtained across the terminals of KB01 as measured with a high-impedance DC volt meter.

Rheostat RB06 can now be used as a fine adjustment to obtain the final setting which gives maximum voltage across the relay coil. These adjustments must be made slowly because of the long time constants associated with capacitance CB01 and the relay coil.

Operation of the relay can now be checked by raising the output voltage above the normal set value to check high voltage operation or by lowering the output voltage below the normal set value to check low voltage operation. Adjustment of the output voltages is accomplished by means of potentiometer RB07 in the regulator circuit. If RB01 and RB06 have been properly set, as described above, relay KB01 should drop out at voltages equally spaced above and below the normal set value, with these voltages being approximately 105 and 95 percent, respectively, of the normal value of 120 volts.

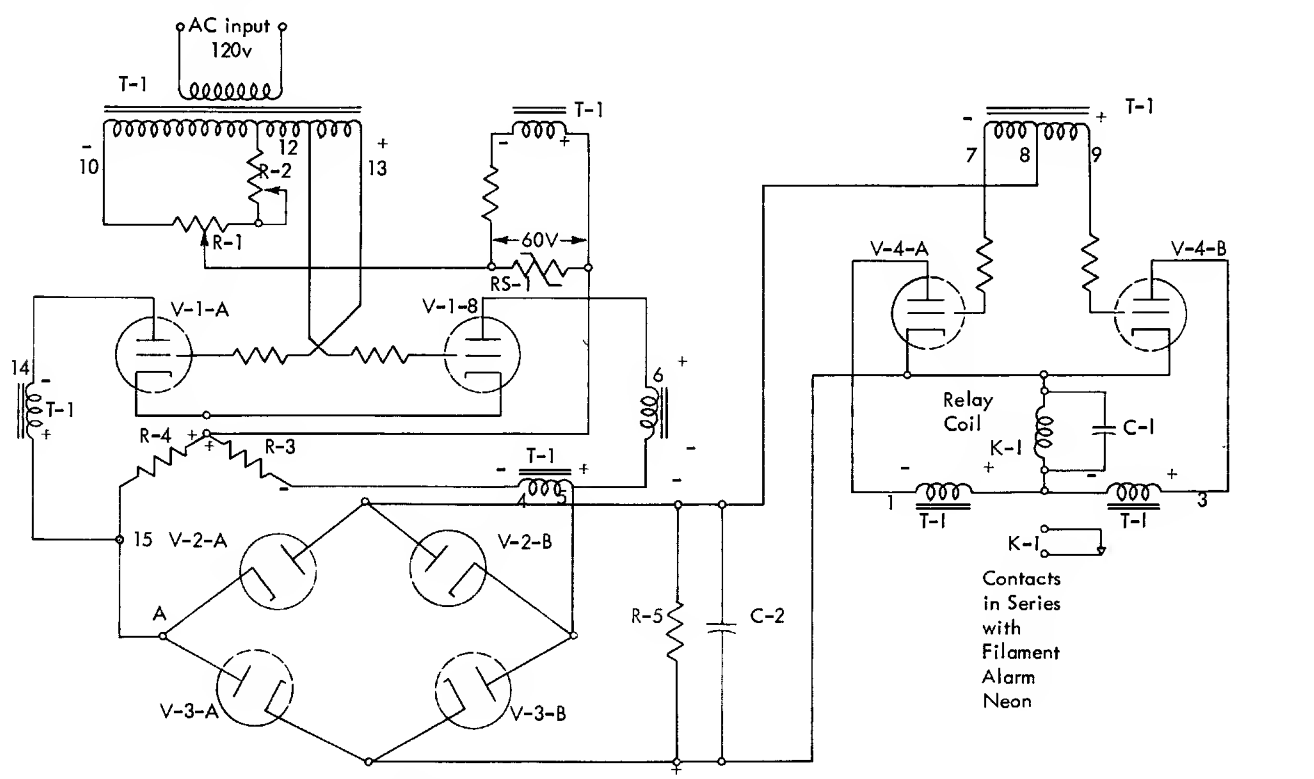


FIGURE 61-9. HIGH-LOW VOLTAGE RELAY CONTROL

PF.62.:0 CIRCUIT ORGANIZATION OF DC POWER SUPPLIES

The table in Figure 62-1 indicates by shaded blocks the various circuits used in each DC supply. The -250v DC power supply, for example, consists of a full-wave thyratron rectifier, single-phase thyratron grid control type of voltage control and a ripple suppressor.

Figure 62-2 shows the -250v DC power supply as a typical supply with its voltage control chassis, ripple suppressor, and associated circuits

Power Supply Circuits		+500v 2 Amp 701 Only	+220v 16 Amp	+150v 60 Amp	+150v 3 Amp	+15v 70 Amp	-30v 40 Amp	-100v 60 Amp	-130v 3 Amp (704-737)	-160v 22 Amp (704-738)	-250v 10 Amp
Principal Use		B + Electrostatic Storage	AND Ckt Supply	Vacuum Tube Ckt B +	Relay Driver B+	Clamp Voltage & Neon Return	Grid Bias & Clamp Voltage	Vacuum Tube Cathode Return (-100C-DPD)	MSD Cathode Return In 737	MSD & DPD Cathode Return In 738	OR Ckt Supply & Amp Cathode Re
Full-Wave, Single-Phase, Gas Diode											
Full-Wave, Single-Phase Thyratron											
Forked WYE, 3-Phase Thyratron											
Full-Wave, Single-Phase, Selenium											
DC Voltage Control	A										
	B										
	C										
Ripple Suppressors											

A - Saturable Reactor Control
B - Three-Phase Thyratron Control
C - Single-Phase Thyratron Control

FIGURE 62-1. POWER SUPPLY CIRCUIT ORGANIZATION

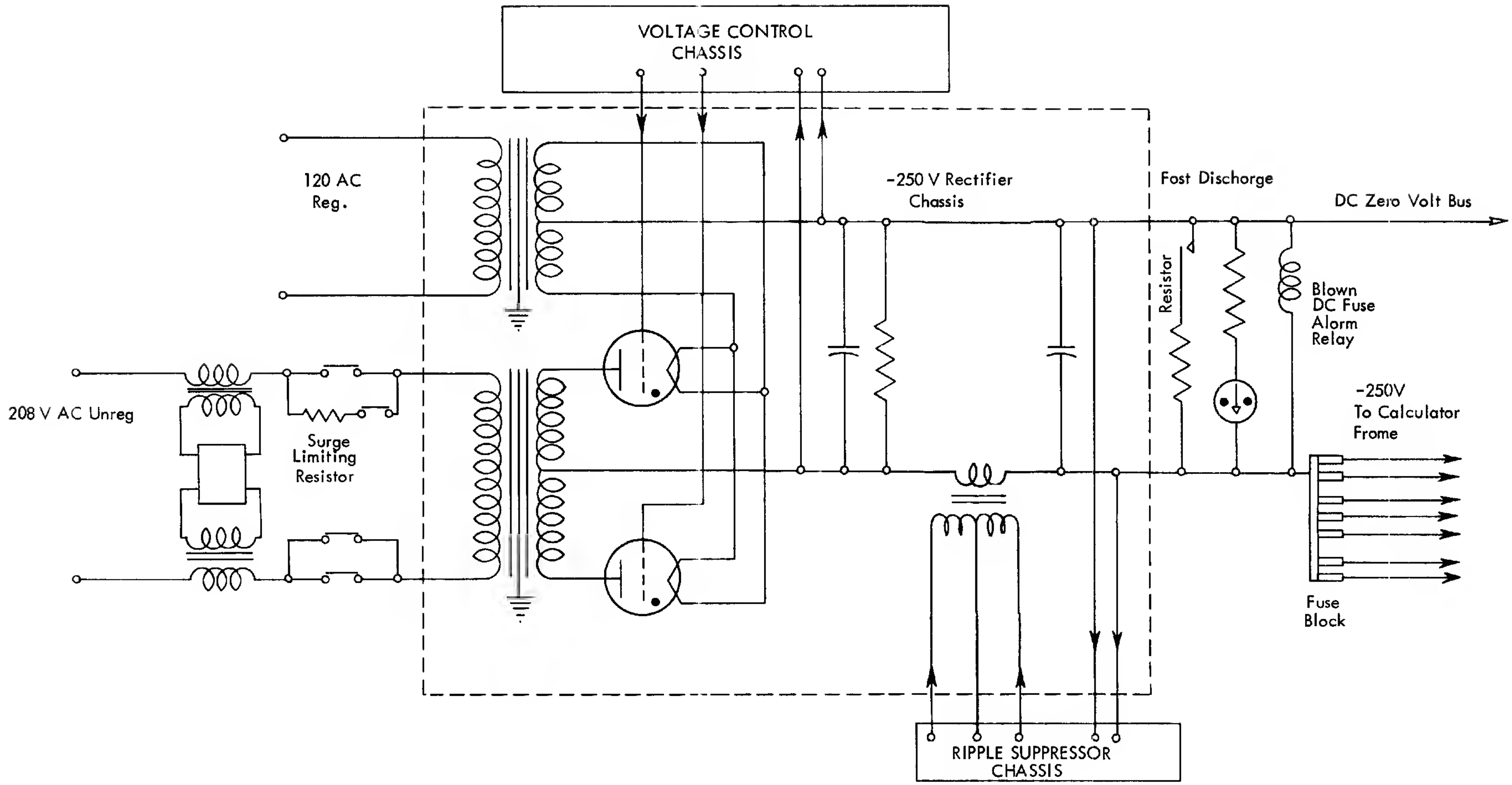


FIGURE 62-2. TYPICAL DC POWER SUPPLY AND ASSOCIATED CIRCUITS

PF.63.00 RECTIFIER CIRCUITS

The various basic types of rectifier circuits used are described below.

PF.63.01 Full-Wave Gas Diode Rectifier

A full-wave rectifier circuit, Figure 63-1, employing an argon filled duo-diode, is used for the +150v, 3-amp supply. Since the ripple need not be restricted to close limits, only a tuned choke and a shunt capacitor filter is connected to the output of the supply.

PF.63.02 Full-Wave Thyratron Rectifier

A full-wave thyratron rectifier, Figure 63-2, is used for the -250v and +220v supplies. A 60-cycle voltage is applied to the plates of the thyratrons and a pulse from the voltage control unit is applied to the thyratron grid to fire the tube. The time at which the pulse is applied to the grid determines the push of the plate voltage cycle during which the tube conducts. This controls the level of the DC output.

To maintain the ripple within the required limits, two banks of shunt compacitors and a ripple-suppressor circuit are connected to the output.

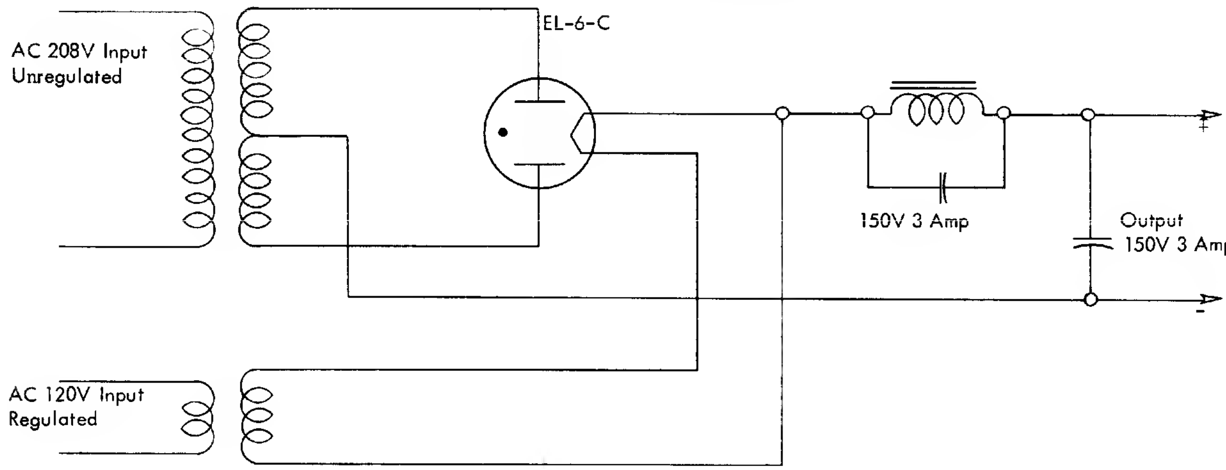


FIGURE 63-1. FULL-WAVE GAS DIODE RECTIFIER

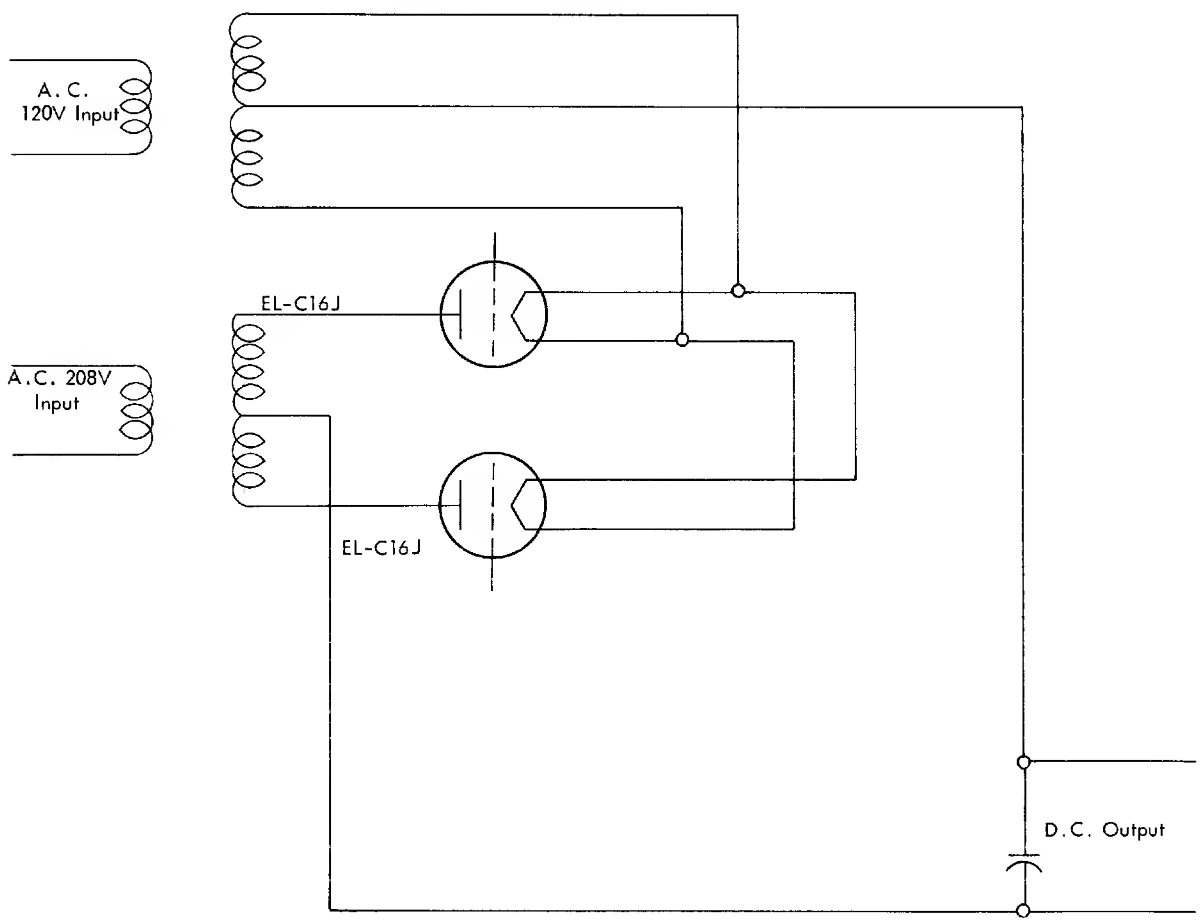


FIGURE 63-2. FULL-WAVE THYRATRON RECTIFIER

PF.63.03 Forked-Wye Rectifier

A forked-wye rectifier, Figure 63-5, is used for the +150v and the -100v, 60-amp supplies. The plate transformer primary windings are delta-connected. The secondary windings are connected in the forked-wye method shown. The three phase, full-wave circuit converts the three phase voltages to six half-wave pulses, 60 degrees apart, in each cycle. Since the EL-C16-J thyratrons are rated at 16-amps each. forked-wye rectifier using six thyratrons can supply a maximum of 96-amps. The outer or branch windings of the forked-wye each carry the current of one anode, but the control or star windings in the center each carry a current of two anodes. A ripple suppressor and two shunt capacitor banks are used to smooth the DC voltage.

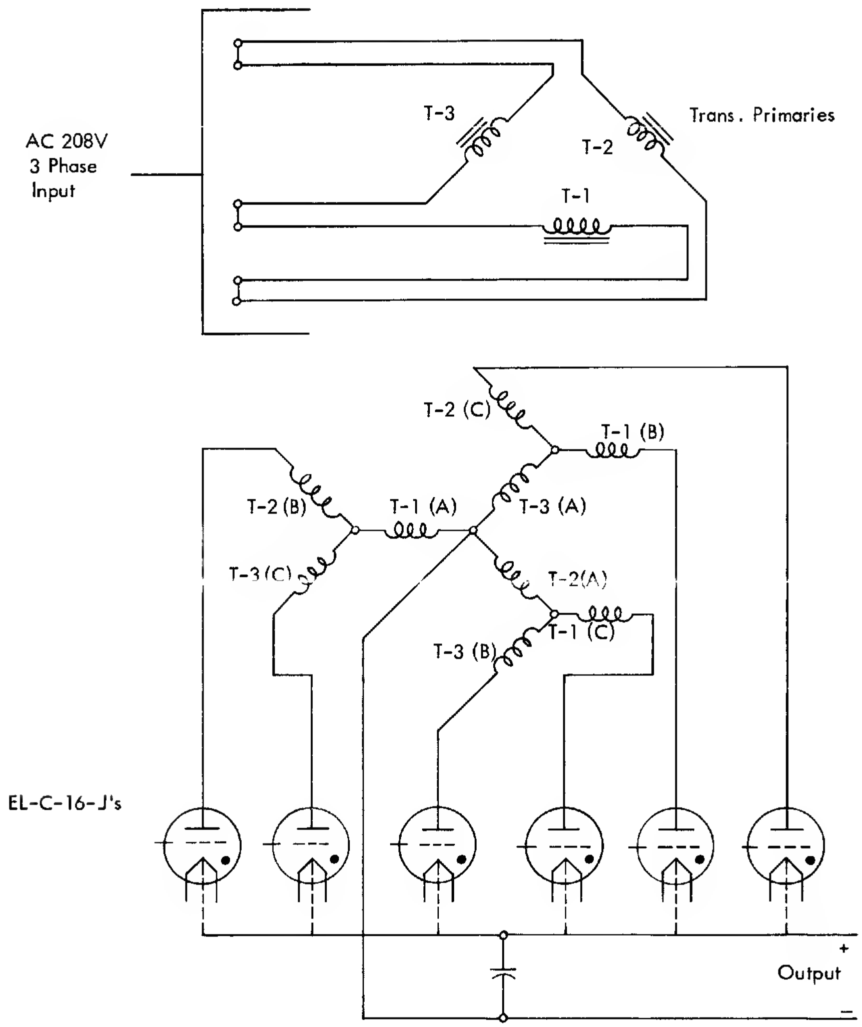


FIGURE 63-3. FORKED-WYE RECTIFIER

PF. 63. 04 Full-Wave Selenium Rectifier With Saturable Reactor Control

The full-wave rectifier circuit shown in Figure 63-4 is used for the +15v and -30v DC supplies, and is quite similar to the one used for the -130v supply. The magnitude of the AC voltage applied to the selenium stacks is controlled by a saturable reactor. As the saturable reactor core saturation is increased because of increased DC current through the windings, the impedance of the load windings in series with the rectifier becomes smaller. Therefore, more of the AC input voltage is applied to the rectifier, resulting in a higher DC output voltage. Conversely, for a decreased core saturation because of decreased DC in the control winding, impedence of the load winding becomes larger, resulting in a smaller AC voltage applied to the rectifier and, therefore, a lower DC output voltage. A feed back winding with a current limiting resistor R is connected across the output of supply. DC current through the control winding is regulated by the voltage control unit. The action of the feed back and control windings in controlling the core saturation is shown in Figure 63-5. Direct current flowing through the feed back winding produces a flux bias which holds the core saturation at point A on the magnetization curve. With this core flux load, the impedence of the load-winding in series with the rectifier is very large, resulting in a small output voltage. However, the load current in the load winding tends to saturate the core to point B on the curve by producing a flux that is in opposition with the flux produced by the feed back winding. This is a self-saturating feature obtained by having the load current in each load winding always flowing in the same direction by the rectifier action. The flux produced is, therefore, always in the same direction, bringing the core flux toward the saturation level. Should the load increase, producing a drop in the output voltage, the self-saturating flux is increased, saturating the core more and decreasing the impedance of the load windings to bring up the output voltage. The flux produced by the control winding aids the self-saturating flux of the load current and is in opposition to the bias flux of the feed back winding. With the voltage control supplying proper current to the control winding, the core is saturated to point C on the magnetization curve. The impedence of the load winding is thereby lowered until rated DC output voltage is obtained from the supply current.

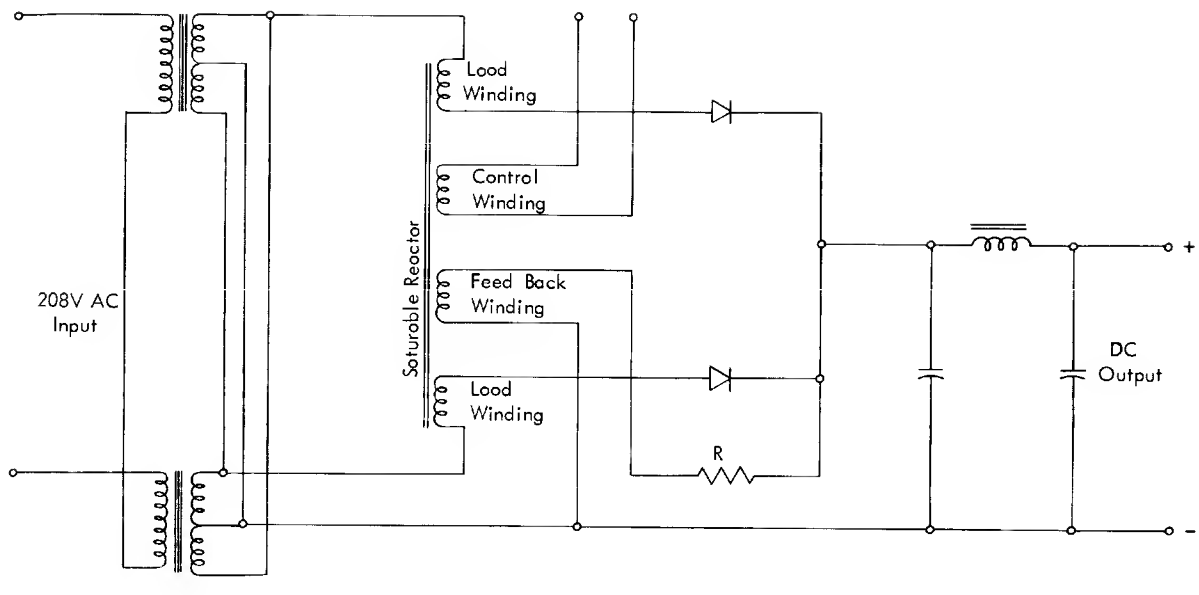


FIGURE 63-4. SATURABLE REACTOR CONTROL OF AC INPUT TO FULL-WAVE SELENIUM RECTIFIER

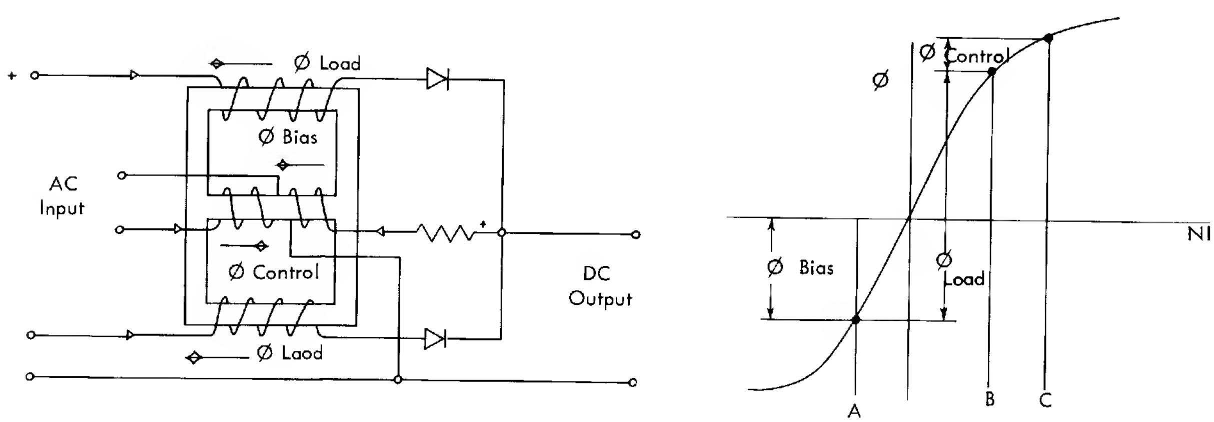


FIGURE 63-5. SATURABLE REACTOR CORE FLUX

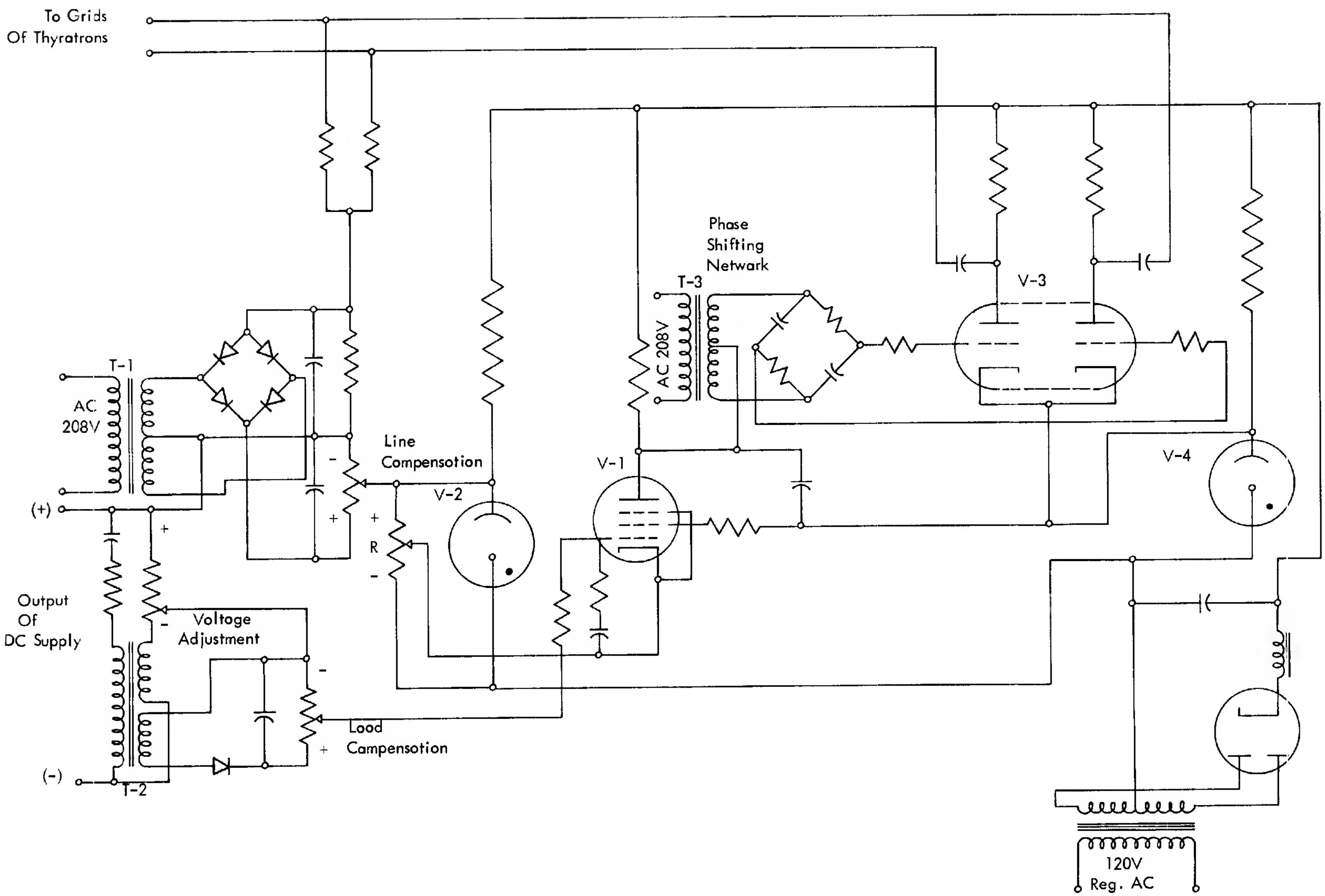


FIGURE 64-1. SINGLE-PHASE THYRATRON-GRID-CONTROL TYPE OF VOLTAGE CONTROL

PF.64.00 VOLTAGE CONTROL UNITS

Each of the DC voltage supplies within the power supply system with the exception of the +150v, 3-amp and the -130v supply incorporates a direct voltage control circuit.

The control provides the following four advantages: gradual application of power to the calculator circuits, regulation of the output of the DC supply, manual adjustment of the regulated DC voltage level, and automatic compensation for line and load variations. A different type of voltage control unit is used for each of the three basic rectifier types.

PF.64.01 Single-Phase Thyratron Grid Control

To maintain the required DC output voltage of the full-wave thyratron rectifiers, a single-phase thyratron grid control type of voltage control is used. A simplified diagram of this voltage control unit is shown in Figure 64-1.

Components of the voltage control include: a voltage adjustment potentiometer (which is connected across the output of the DC supply), a pentode amplifier (V-1), a voltage reference tube (V-2), and a dual triode amplifier (V-3). The plates of V-3 are connected to the grids of the thyratrons in the rectifier circuit of the DC supply through a differentiating circuit. The grids of V-3 are fed from the plate of V-1 through a phase shifting network and a transformer winding, T-3, which furnishes a 60-cycle voltage in phase with the thyratron plate voltage. The theoretical wave shapes of the DC voltage control unit in Figure 64-2 show how the firing of the thyratron is controlled.

The alternating voltage impressed on the grid of V-3 leads the alternating voltage impressed on the plates of the thyratrons by a 90-degree phase angle. This voltage is obtained by applying a 60-cycle voltage in phase with the thyratron plate voltage through a phase shifting network. The level of the alternating voltage on the grid of V-3 is determined by the DC bias on the grid as obtained from the plate voltage of V-1. For a high-level DC bias, the superimposed alternating voltage does not extend below cut off potential of V-3. Thus, the plate potential of V-3 is at a low level during the alternating voltage cycle. As the DC bias is lowered, the tube cuts off during a portion of the negative half-cycle. During cut-off, a positive output pulse on the plate of V-3 is obtained. By differentiating this positive pulse, a thyratron-firing pulse is obtained.

The alternating voltage on the grid of V-3 is leading the thyratron plate voltage by 90 degrees. The positive-firing pulse applied to the thyratron's grid appears during some portion of the positive half-cycle of the thyratron plate voltage wave form. By raising and lowering the level of the DC bias on the grid of V-3, the position of the firing pulse (with respect of the voltage wave form appearing on the thyratron plate) is variable and determines the point at which the thyratron conducts. Before the thyratrons and rectifier circuit are initially fired, V-3 conducts heavily with grid current flowing. Tube V-1 is cut off and V-2 is supplying a closely regulated direct voltage.

To initiate circuit operation, power is supplied to the Haydon timer motor which rotates the potentiometer R. This potentiometer goes from minimum to maximum voltage in 30 seconds to raise the grid voltage gradually on V-1. The plate potential of V-1 decreased with the increase in the grid potential, thus lowering the DC bias on the grid of V-3 and a level of the superimposed alternating voltage. As the average direct grid voltage on V-3 goes more negative, the plate voltage rises earlier in the cycle, the thyratron fires early in its plate voltage cycle and delivers a greater average volt-ampere output to the load until rated output is reached.

Voltage Adjustment Potentiometer. This potentiometer is used to adjust the rated DC output voltage of a supply. For a fixed adjustment, it tends to maintain the supply voltage at that constant level.

When the output voltage of the supply decreases, the voltage across the voltage adjustment potentiometer (Figure 64-1) decreases and the grid of V-1 becomes more positive relative to the cathode. As the grid potential rises, the plate potential falls. The DC grid voltage of triode V-3 falls with the plate potential of V-1 and the triode plate potential rises at an earlier part of the cycle to pulse the thyratron earlier in its plate voltage cycle, resulting in an increased output. Thus, the DC output voltage is brought back up to normal.

Line Compensation Potentiometer. A line compensation potentiometer is used to maintain a constant DC supply output voltage with changes in the applied AC line voltage. A rectified voltage (proportional to the line voltage) appears across the line-compensating potentiometer. This is a negative voltage as applied to the grid of V-1. For a decreased applied line voltage, less voltage is developed across the line-compensating potentiometer and the grid of V-1 becomes more positive relative to its cathode. The plate potential of V-1 decreases, lowering the DC bias on the grid of V-3. This causes the plate potential of V-3 to rise earlier in the cycle, firing the thyratron earlier. Thus, the average volt-amperes and output voltage tend to remain the same even with the decreased line voltage applied to the thyratron plates.

Load Compensation Potentiometer. The voltage across a load compensation potentiometer is used to adjust the DC output voltage of a supply for variations in load. The ripple content of the DC supply output increases with an increase in load on the rectifier. This ripple voltage is isolated from the DC supply output voltage by a step-up transformer T-2. The ripple component across the secondary of the transformer is rectified and applied to the load compensation potentiometer. The voltage across the potentiometer is a positive voltage as applied to the grid of V-1. For an increased load on the DC supply, the voltage across the potentiometer increases, making the grid of V-1 more positive. This lowers the plate potential of V-1 and the DC bias on the grid of V-3.

Haydon Timer Circuit Operation. The output voltage of each of the DC supplies, with the exception of the -30v, +15v, -130v, and +150v, 3-amp supplies is brought up to rated value gradually by a motor-driven potentiometer in the voltage control unit.

The Haydon timer motor and potentiometer circuit used is shown in Figure 64-3. The timer motor rotates the potentiometer R until the point of maximum level is reached. At this time micro-switch contacts are mechanically closed to pick up relay K1. The normally opened K-1-A points closed to hold the relay energized. The normally-opened K-1-B points closed connect the full negative voltage across the potentiometer to the cathode of tube V-1 and the normally closed K-1-A points open the circuit to the Haydon timer motor, allowing the timer and potentiometer to return to the normal position.

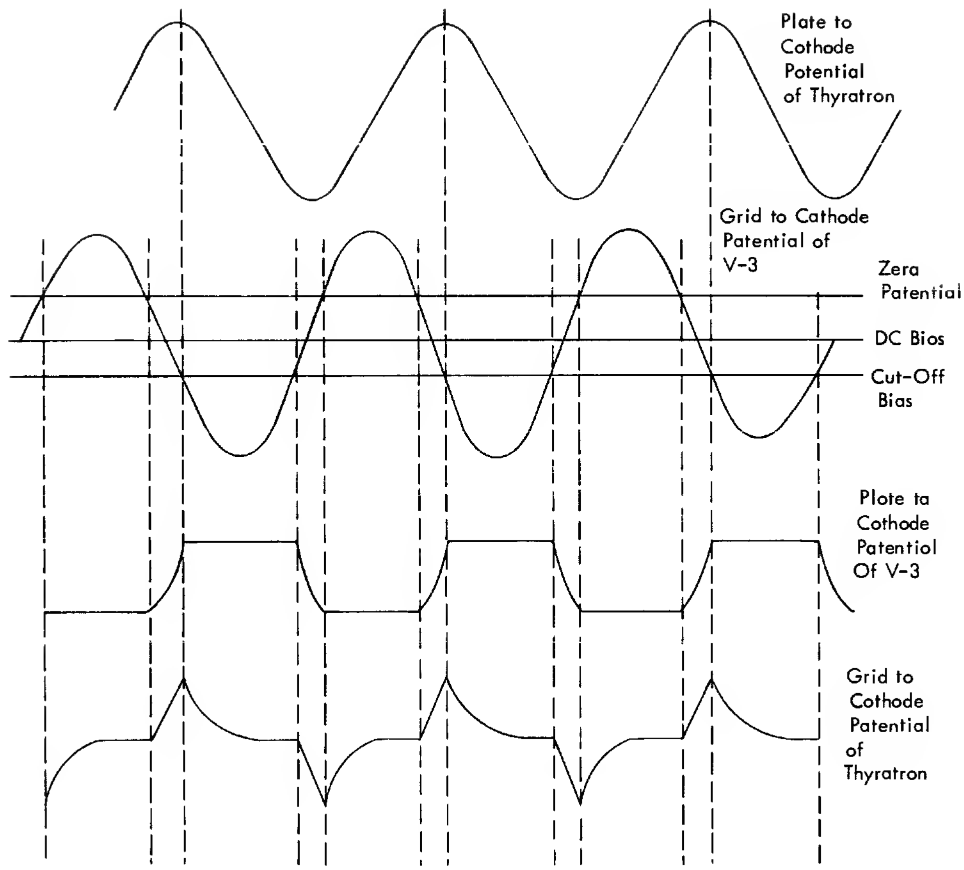


FIGURE 64-2. THEORETICAL WAVE SHAPES OF THYRATRON VOLTAGE CONTROL

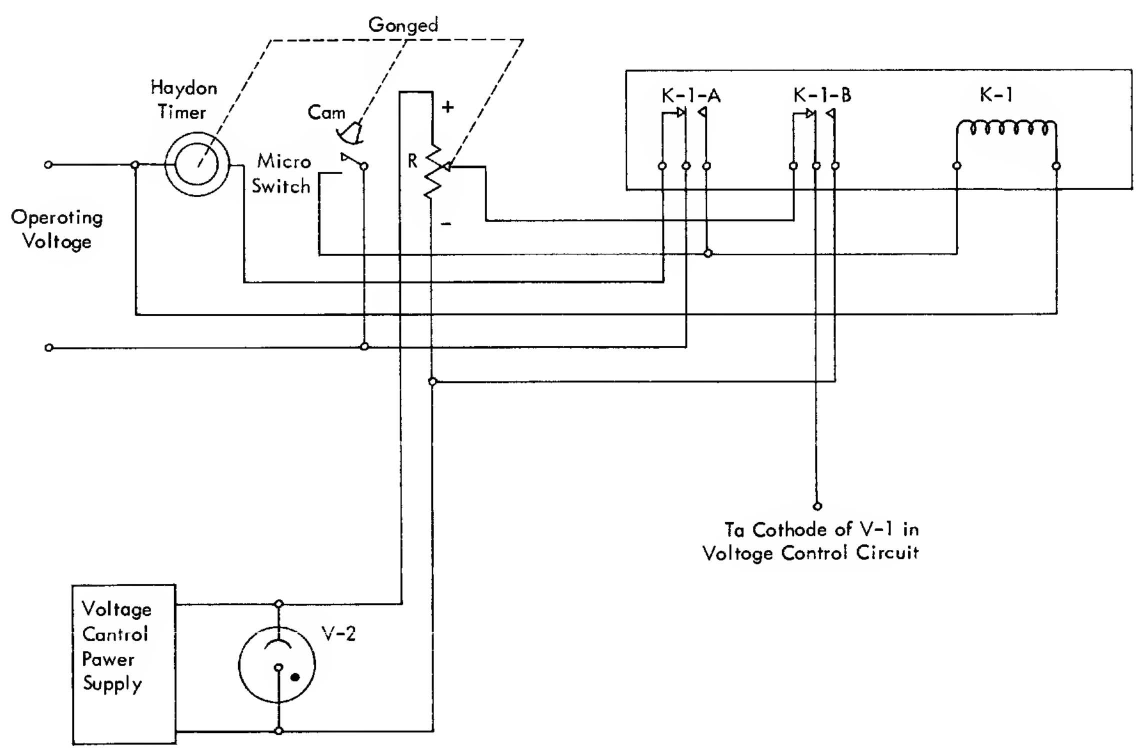


FIGURE 64-3. HAYDON TIMER CIRCUIT

PF. 64. 02 Three Phase Thyratron Grid Control

Figure 64-4 shows a simplified schematic of the three-phase thyratron-grid voltage-type voltage control unit which is used to control the output of the -100 and +150v DC supplies. This type of voltage control is similar in operation to the single-phase thyratron grid control unit. Since the forked-wye rectifier supply requires control of six thyratron grids, a three-phase voltage control unit using three duo-triode amplifiers (V-3) is used.

The alternating voltages applied to the grids of the three duo-triodes are obtained from the secondaries of a three-phase transformer; T-1, the primary voltage of which is in phase with the three-phase voltage applied to the plates of the thyratrons. Firing pulses that operate a particular thyratron are obtained from the differentiated plate output of a duo-triode having an impressed alternating grid voltage 90 degrees out of phase with the thyratron plate voltage.

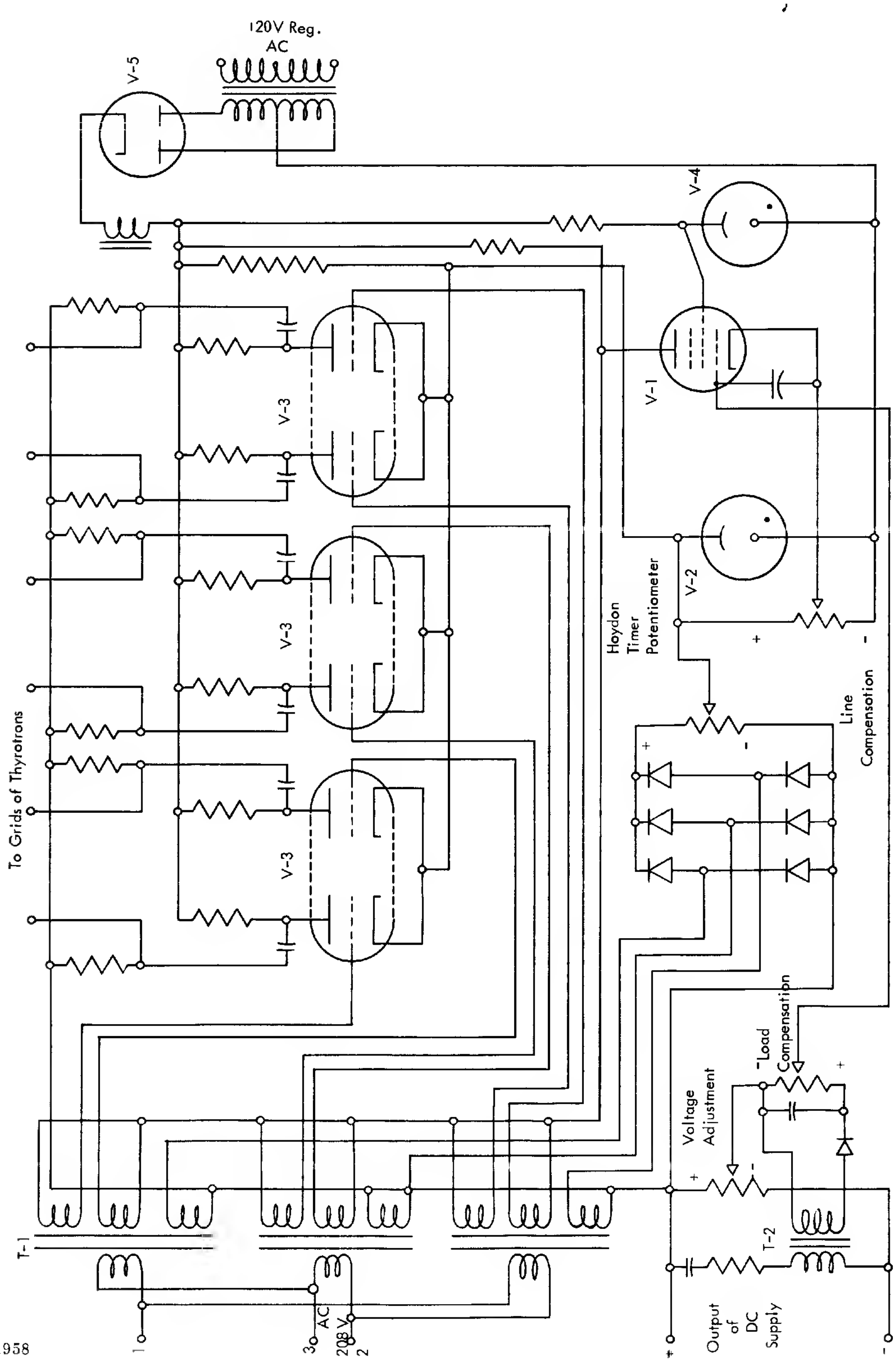


FIGURE 64-4. THREE-PHASE THYRATRON-GRID-CONTROL TYPE OF VOLTAGE CONTROL

The DC bias on the grids of V-3 controls the cut-off duration of the tube and the phase relation of the firing pulses just as for the single phase thyratron grid control type of voltage control. The level of this DC bias is set by the plate potential of V-1 applied to the grids of V-3 through the secondary winding of the three-phase transformer. The operation of the voltage adjustment, load compensation, line compensation and Haydon timer potentiometers in maintaining the DC supply output voltage is the same as for the single-phase unit.

PF 64.03 Saturable Reactor Voltage Control

To control the core saturation of the saturable reactor in the -30 and +15v supplies and, therefore, the DC output voltage, the current through the control winding and the saturable reactor is regulated by the direct-voltage-control circuit as shown in simplified form in Figure 64-5. The voltage control unit for the -130v rectifier is basically the same and is not covered separately.

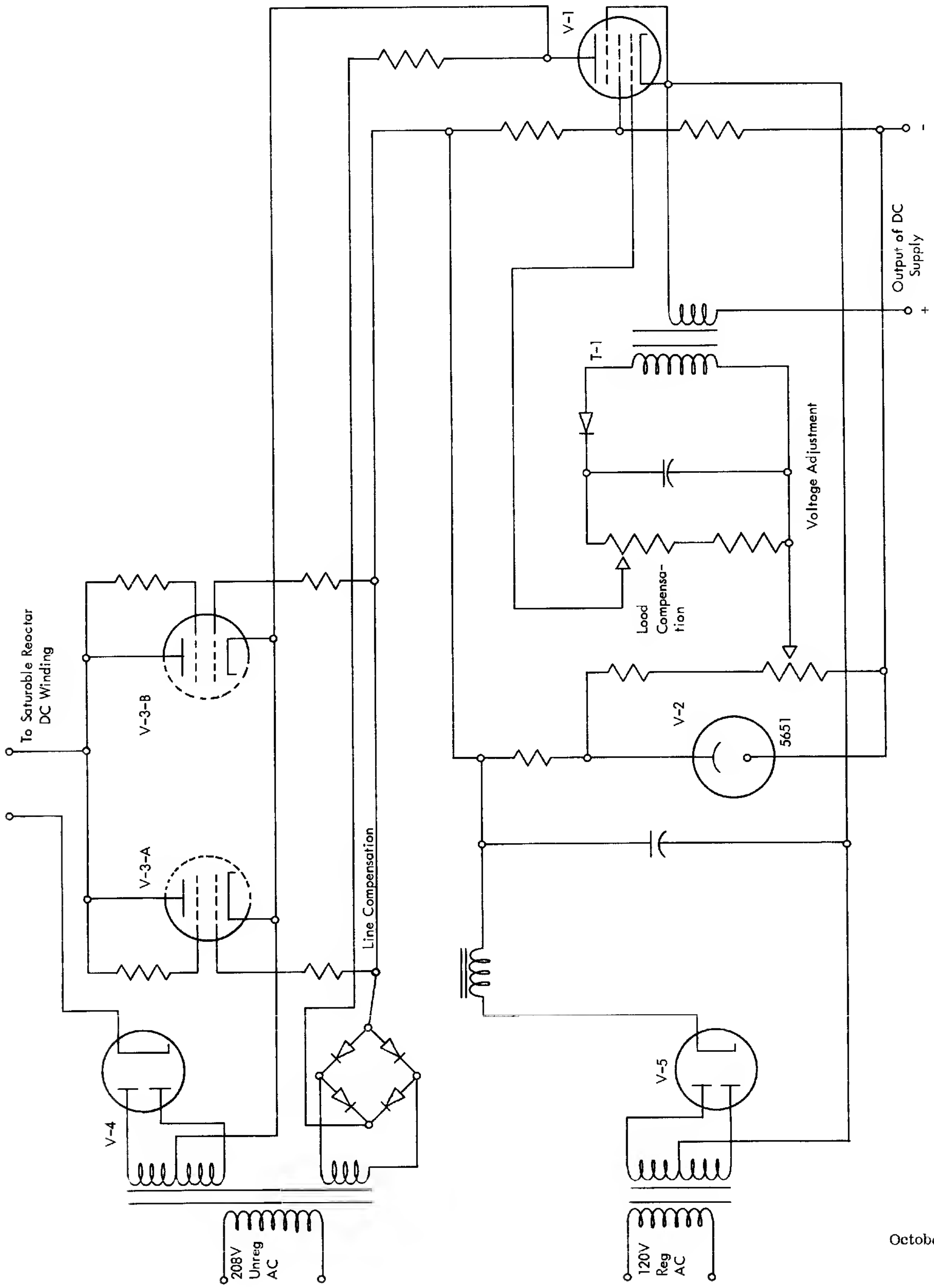


FIGURE 64-5. SATURABLE REACTOR VOLTAGE CONTROL

The current regulator tube V-3 determines the amount of DC current that is furnished to the control winding of the saturable reactor through the rectifier tube V-4. The output voltage of the DC supply is impressed on the grid of tube V-1 through the voltage adjustment and load compensation potentiometers. Assuming that the potentiometers are initially adjusted to the zero resistance, the output voltage of the supply causes the grid voltage of tube V-1 to be negative with respect to its cathode voltage.

V-2 is a constant-voltage tube, and therefore, the voltage across the voltage adjustment potentiometer remains constant. Moving the tap of the voltage adjustment potentiometer upward makes the grid of V-1 less negative with respect to its cathode and V-1 conducts more heavily. With increased conduction, the plate voltage of V-1 and the cathode voltage of V-3 becomes more negative. As the cathode voltage of V-3 becomes more negative with respect to the grid, the current regulator tube conducts more heavily. This increases the DC current flowing through the rectifier tube of V-4 and the saturable reactor control winding.

For a fixed position of the voltage adjustment and load compensation potentiometers, assume that the output of the DC supply increases. For example, the +15v supply increases from +15 to 17 volts. The second grid of V-1 becomes more negative with respect to its cathode, decreasing conduction and raising the plate voltage of V-1 and the cathode voltage of V-3. Since the cathode voltage of V-3 is now more positive than before, the condition of V-3 decreases and the magnitude of DC current flowing through the control winding is decreased. Core saturation, therefore, decreases, thus increasing the impedance of the load windings in series with the selenium rectifiers. Since a smaller AC input voltage is applied to the rectifier, a smaller DC output is obtained and the supply tends to regain the plus 15 volt output level.

For a decreased DC voltage supply, a similar analysis shows that the DC current in the control winding of the saturable reactor is increased, decreased in the impedence of the load windings and increased in the DC output voltage.

Load compensation is obtained by supplying a positive voltage to the grid of V-1 that increases in proportion to any increase in load. The ripple voltage in the supply output voltage is isolated by transformer T-1, rectified, and applied to the load compensation potentiometer. As the load increases, the grid of V-1 becomes more positive, driving the plate voltage of V-1 and a cathode voltage of V-3 more negative. Current-regulator tube V-3, conducts more to supply a greater DC current to the control winding of the saturable reactor. The resultant increase and output voltage of the supply compensates for the increased load which is tending to lower the output voltage.

Compensation for changes in line voltage is achieved by the line-compensation bridge rectifier. The bridge rectifier supplies a negative voltage to the grids of V-3, thereby controlling the magnitude of current supplied to the control winding. Decreased AC line voltages decreases this negative voltage to the grids of V-3 and allows greater current to be supplied to the control windings. The result in decrease and impedence of the saturable reactor load windings compensates for the decrease in AC line voltage applied to the supply rectifier then the voltage control unit.

PF.65.00 RIPPLE SUPPRESSOR

Five of the DC voltage supplies have an associated ripple suppressor to smooth out any voltage variations remaining. The maximum ripple voltage allowed for each supply at the fuse blocks in the power distribution frame is as follows:

Output Voltage	Maximum Ripple Voltage Peak to Peak, Millivolts
+500	100
+220	50
+150	250
-30	250
-100	250
-250	250
-15	500

The ripple-suppressor circuit as shown in the simplified diagram, Figure 65-1, consists of a transformer, T-1, the secondary of which is connected in series with the zero-volt output lead of the main rectifier, and auxiliary power supply, V-6, and a control circuit for supplying current to the primary winding of transformer, T-1.

Pentode V-1 amplifies the ripple component in the output voltage appearing across capacity C2. This amplified ripple is applied to the phase inverter stage, V-2, which controls the current regulator tubes V-3 and V-4. Changing plate current in the current regulator tubes, through the primary of transformer T-1, induces voltage in the secondary winding of T-1 which adjusts for a variation in the output voltage of the supply.

The operation of the ripple suppressor for a variational rise in the output voltage across C2 is considered. With the rise in the output voltage, the grid-to-cathode voltage of pentode V-1 becomes more positive, increasing the plate current flow. The plate voltage of V-1 decreases with the increased voltage drop across the plate resistor. Since the plate of V-1 is resistance-capacitance coupled to the grid of V-2A, the grid-to-cathode voltage of V-2A becomes more negative. Plate voltage of V-2A increases to make the grid-to-cathode voltage of V-3 more positive. This increases the plate-current flow of V-3. A portion of the increased plate voltage of V-2A is applied to the grid of V-2B through resistor R-1 causing V-2B to conduct more. The plate voltage of V-2B decreases to make the grid-to-cathode voltage of V-4 more negative. As the grid-to-cathode voltage becomes more negative, the plate current of V-4 decreases.

Therefore, as the voltage rises across C2, the plate current of V-3 increases while the plate current of V-4 decreases. Since the current is leaving the primary winding of T-1 at point A and increasing in the left-half of the winding and decreasing in the right-half of the winding, the polarity of the primary winding is as shown. The voltage, thereby induced in the secondary winding of T-1, subtracts from the voltage appearing across the capacitor C1 and consequently opposes the rise in voltage across C2.

With an assumed variational drop in voltage across C2, the action would be reversed and the voltage induced in the secondary of T-1 would add to the voltage appearing across C1 consequently oppose the drop in voltage across C2.

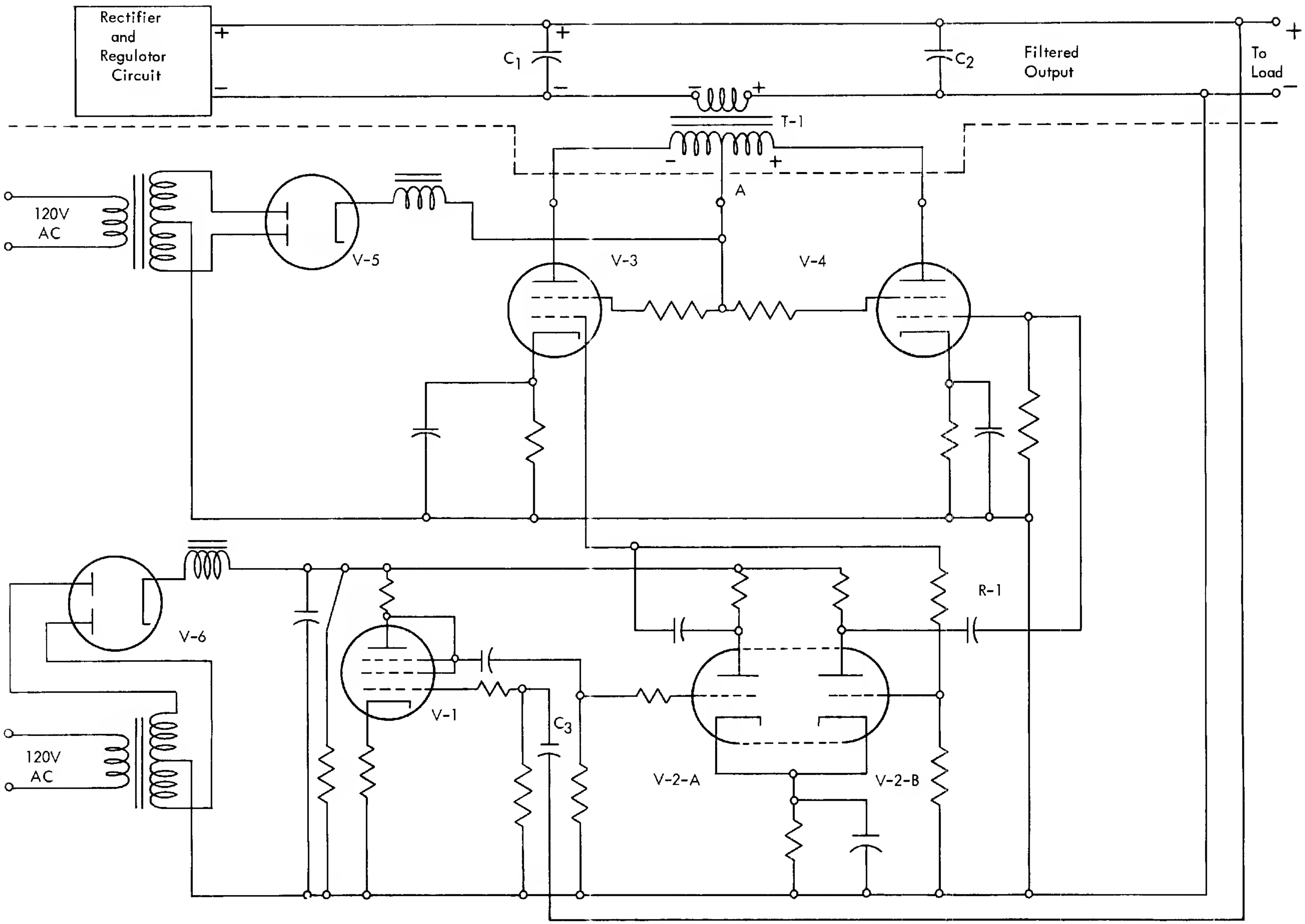


FIGURE 65-1. RIPPLE SUPPRESSOR CIRCUIT